

Experimental and Research Station,

Nursery & Market Garden Industries'

- - Development Society, Limited. - -

Turner's Hill, Cheshunt, Herts.

Eighth Annual Report,
1922.

THE CHESHUNT PRESS, LIMITED.

1923.

Nursery and Market Garden Industries' Development Society, Limited.

OFFICERS 1922-23.

President:

† H. O. LARSEN, Esq., J.P., C.C., D.C.

Hon. Treasurer:

† C. H. SHOULTS, Esq.

Committee of Management:

* PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., F.R.S.

* PROFESSOR V. H. BLACKMAN, M.A., Sc.D., F.R.S.

A. S. BOWLBY, Esq., J.P., C.C. (Herts County Council).

E. A. BOWLES, Esq., M.A., F.E.S., F.L.S. (Middx. County Council).

† J. C. COBLEY, Esq.

† W. DYKE, Esq.

ALDM. A. J. EDWARDS, D.L., J.P. (Essex County Council).

* PROFESSOR J. B. FARMER, M.A., D.Sc., F.R.S.

† J. HARNETT, Esq.

† A. J. HENRIKSEN, Esq.

A. B. LISTER, Esq., A.R.C.Sc., D.I.C., B.Sc.

† J. P. ROCHFORD, Esq.

* SIR JOHN RUSSELL, O.B.E., D.Sc., F.R.S.

† E. S. SHOULTS, Esq.

* DR. J. A. VOELCKER, M.A., Ph.D.

Auditors:

MESSRS. GEORGE COBLEY, KAY & Co, 27, Southampton Street,
Strand, W.C.

Bankers:

THE LONDON JOINT CITY & MIDLAND BANK, LIMITED.

Solicitors:

MESSRS. HUTCHISON & CUFF, 6, Stone Buildings,
Lincoln's Inn, W.C.

*Nominated by the Committee of the Lawes' Agricultural Trust, Rothamsted,
Harpenden, Herts.

† Nominated by the Lea Valley and District Nurserymen's and Growers'
Association, Limited.

Experimental and Research Station.

SCIENTIFIC STAFF.

DIRECTOR :

W. F. BEWLEY, D.Sc. (Dunelm).

ENTOMOLOGIST :

E. R. SPEYER, M.A. (Oxford).

* CHEMISTS :

L. B. TIMMIS, M.Sc. (Tech.) A.I.C.

O. OWEN, B.Sc. (Wales), A.I.C.

SECRETARY :

HELEN MARCHANT.

GLASSHOUSE WORKING STAFF.

Foreman.....A. A. Richards.

Cucumber Grower.....J. H. Smith.

Tomato Grower.....A. E. Judd.

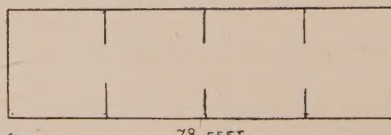
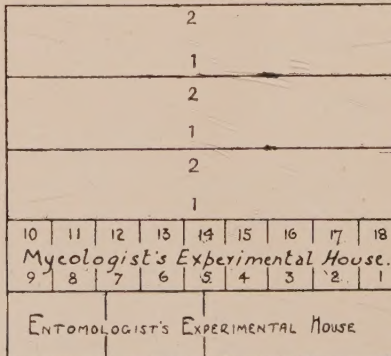
Tomato Grower.....W. R. Everard.

Tomato Assistant.....G. J. Wilkinson.

* Special Investigators for Carbon Dioxide Work.

— CUCUMBER HOUSES —

SERIES D. SERIES E. SERIES F.



— ISOLATION HOUSE —

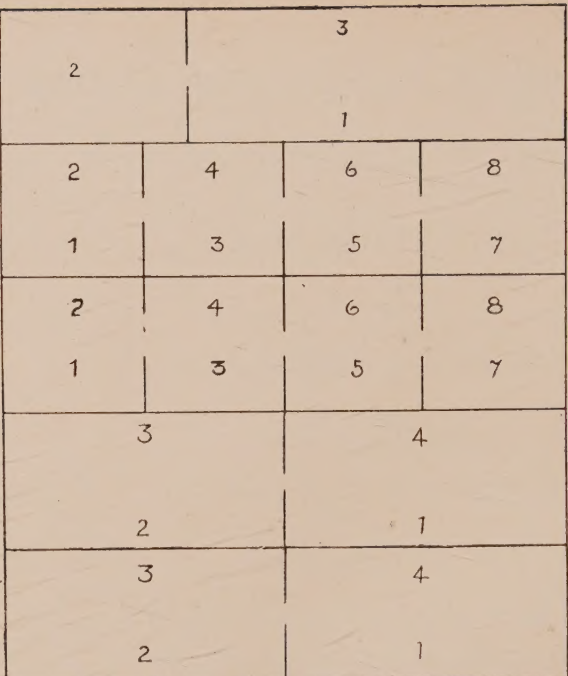
— TOMATO HOUSES —

SERIES G.

SERIES H.

SERIES J. SERIES K.

SERIES M.



100 FEET



100 FEET

26 FEET

— Roadway —

Stakehole and Boiler

Garden Border

Stakehole and Boilers

Water Tower

Packing and Store Shed

— Roadway —

Botanical Laboratory.

Chemical Laboratory.

Office

Dark Room

Laboratory

Diagram —
— to show
arrangement of
experimental plots

— 1922 —

General Report.

IT is a pleasure to report that the Nursery and Market Garden Industries' Development Society, Limited, continues to make steady progress in its many activities throughout Great Britain and Ireland and is extending its influence to other parts of the world.

Members will agree that, in the interests of the industry, it is desirable that every grower should take advantage of the advisory and research facilities of the Experimental Station, where horticultural problems are being investigated. The effective control of diseases and pests is only possible when every grower takes full advantage of existing methods.

Complete co-operation between the grower and scientific worker must lead ultimately to the solution of the many problems which are of so much economic importance to the grower. The Station staff hope that every member will make a special point of watching the experiments throughout the season, and assist by helpful criticism and suggestion.

It is a pleasure to report that the income from Annual Subscriptions in 1922 was £160 more than in 1921.

The deficit on the Capital Debt at the end of 1922 was £240, the amount having been reduced by £159 during that year, while that on the Maintenance Account was £889, being £93 more than that of the previous year.

The number of visits from growers and others amounted to 907 during the past year. This is considerably less than that for 1921, but previously the number included visitors, mainly commercial, to the Lea Valley Growers' Association and Nursery Trades, Limited, whose headquarters were at the Station.

Experiments conducted with tomatoes during the past year were mainly a repetition of those carried out in 1921. The programme has been completely revised and a new one arranged for 1923. The cucumber experiments were conducted to determine the effect of different base treatments upon crop yield. The effect of pollinating a number of flowers on each plant was also tested in relation to crop yield and resistance to disease.

At the request of the Ministry of Agriculture, who provided a special grant, preliminary investigations were started to determine if increased crops could be obtained by artificially increasing the concentration of Carbon Dioxide in glasshouse atmospheres. From May to September the work was carried out by Mr. L. B. Timmis, M.Sc., who was succeeded by Mr. O. Owen, B.Sc., in October. Results of value have been obtained, and the work is being continued during 1923.

Experimental Results of 1922.

The practice of grading the tomato fruits adopted in 1921 was continued during the present season, but a slight modification of the grades was made as it was felt desirable to separate the "Blues" and the "Whites," which in 1921 were grouped together under "Grade B." The fruits are collected from each plot in numbered "strikes" or baskets, and graded into seven grades as follows:—

- A.—"Pinks" and "Pink and Whites." These are the best quality of fruit in size, shape and colour; "Pinks" being slightly larger than "Pink and Whites."
- B.—"Whites." These are fruit of good shape and colour but smaller than "Pink and Whites."
- C.—"Blues." This grade consists of fruit of good colour, but larger and more irregular in shape than Grade A.
- D.—"Roughs." Small misshapen fruits about the size of cherries.
- E.—Blotchy fruits which ripen irregularly.
- F.—Fruits showing Blossom End Rot.
- G.—Fruits showing lesions of "Stripe Disease."

Experiments in the Cultivation of Tomatoes

(a) Mulching Experiment.

This experiment was begun in 1920, on eight small plots in House 5. During 1921 and 1922 the experiment was repeated on a large scale in Houses 1 and 2. In 1921 four plots were set up, two in House 1 and two in House 2, but during 1922 four plots were arranged in each house to overcome the possibility of the experiments being vitiated by the previous season's mulching. Of the four plots in House 1, Series G., G₁ and G₃ had no mulch, while G₂ and G₄ were mulched with dung. In House 1, Series H, H₁ and H₃ had no mulch, while H₂ and H₄ were mulched with straw. The results, given in Tables I.—VIII. show practically no difference in yield between the mulched and unmulched plots. The straw mulched plots produced yields some 7% greater than the average yield of the unmulched plots.

As this experiment will be discontinued in 1923, the results during the past three years have been drawn together in Table IX. The ultimate conclusion from these experiments is that under the conditions of the experiment, an increased yield is not obtained by mulching. Such results are sufficiently striking to warrant a repetition of the experiment by practical growers under commercial conditions. It must be remembered, however, that unmulched plots require a greater quantity of water

than mulched plots; the mulch preventing the rapid evaporation of water from the soil surface. In this respect mulching is beneficial.

Table I.

G1. No Mulch. Variety—"Ailsa Craig." House No. 1.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
* A.	.45	1.44	.26	.35	.26	2.76	19.32	52.28
* B.	.22	.59	.14	.15	.25	1.35	9.45	25.57
* C.	.10	.32	.06	.06	.05	.59	4.13	11.18
* D.	.16	.10	.04	.05	.12	.47	3.29	8.90
* E.	—	—	—	—	—	—	—	—
* F.	.01	—	—	.02	.01	.04	.28	.75
* G.	—	.01	.01	.03	.02	.07	.49	1.32
Total	.94	2.46	.51	.66	.71	5.28	36.96	100

Table II.

G2. Dung. Variety—"Ailsa Craig." House No. 1.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
* A.	.35	1.50	.22	.31	.39	2.77	19.39	53.89
* B.	.18	.61	.11	.15	.21	1.26	8.82	24.51
* C.	.09	.32	.05	.10	.05	.61	4.27	11.87
* D.	.11	.09	.03	.07	.12	.42	2.94	8.17
* E.	—	—	—	—	—	—	—	—
* F.	—	—	—	—	—	—	—	—
* G.	—	.01	.01	.04	.02	.08	.56	1.56
Total	.73	2.53	.42	.67	.79	5.14	35.98	100

Table III.

G3. No Mulch. Variety—"Ailsa Craig." House No. 1.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.34	1.13	.31	.30	.27	2.35	16.45	44.68
B.	.17	.85	.16	.20	.16	1.54	10.78	29.29
C.	.12	.36	.08	.10	.10	.76	5.32	14.43
D.	.15	.18	.05	.09	.08	.55	3.85	10.46
E.	—	—	—	—	—	—	—	—
F.	—	—	—	.02	—	.02	.14	.38
G.	—	—	.01	.02	.01	.04	.28	.76
Total	.78	2.52	.61	.73	.62	5.26	36.82	100

Table IV.

G4. Dung Mulch. Variety—"Ailsa Craig." House No. 1.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.53	1.35	.22	.26	.10	2.45	17.15	46.14
B.	.23	.70	.16	.15	.13	1.38	9.66	25.99
C.	.13	.37	.10	.15	.06	.81	5.67	15.25
D.	.16	.14	.07	.09	.14	.60	4.20	11.30
E.	—	—	—	—	—	—	—	—
F.	—	—	—	.01	—	.01	.07	.19
G.	—	.01	.01	.03	.01	.06	.42	1.13
Total	1.05	2.57	.56	.69	.44	5.31	37.17	100

Table V.

H1. No Mulch. Variety—"Ailsa Craig." House No. 2.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.59	1.40	.22	.25	.14	2.60	18.20	46.84
B.	.29	.81	.19	.20	.22	1.71	11.97	30.81
C.	.13	.26	.09	.05	.02	.55	3.85	9.91
D.	.17	.13	.10	.08	.07	.55	3.85	9.91
E.	—	—	—	—	—	—	—	—
F.	—	—	—	—	—	—	—	—
G.	.01	.02	.05	.03	.03	.14	.98	2.53
Total	1.19	2.62	.64	.61	.48	5.55	38.85	100

Table VI.

H2. Straw Mulch. Variety—"Ailsa Craig." House No. 2.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.65	1.54	.31	.22	.19	2.91	20.37	49.49
B.	.29	.85	.18	.15	.21	1.68	11.76	28.60
C.	.11	.26	.11	.08	.06	.62	4.34	10.53
D.	.18	.11	.09	.06	.08	.52	3.64	8.84
E.	—	—	—	—	—	—	—	—
F.	—	—	—	—	—	—	—	—
G.	—	.02	.02	.03	.08	.15	1.05	2.54
Total	1.23	2.78	.71	.54	.62	5.88	41.16	100

Table VII.

H3. No Mulch. Variety—"Ailsa Craig." House No. 2.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.57	.93	.40	.22	.13	2.26	15.75	43.39
B.	.34	.65	.24	.20	.27	1.70	11.85	32.65
C.	.09	.20	.10	.06	.07	.52	3.62	9.97
D.	.16	.10	.11	.09	.10	.56	3.90	10.74
E.	—	—	—	—	—	—	—	—
F.	.01	—	—	—	—	.01	.07	.19
G.	—	.01	.02	.06	.07	.16	1.11	3.06
Total	1.18	1.89	.87	.63	.64	5.21	36.30	100

Table VIII.

H4. Straw Mulch. Variety—"Ailsa Craig." House No. 2.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.73	1.32	.32	.28	.13	2.78	19.36	50.25
B.	.31	.61	.16	.14	.20	1.42	9.89	25.68
C.	.16	.24	.14	.10	.06	.70	4.88	12.67
D.	.17	.10	.09	.08	.08	.52	3.62	9.40
E.	—	—	—	—	—	—	—	—
F.	—	—	—	—	—	—	—	—
G.	—	.01	.03	.03	.04	.11	.77	2.00
Total	1.37	2.28	.74	.63	.51	5.53	38.52	100

Plots G1, G2, G3, G4, H1, H2, H3, and H4 were each 50ft. by 13ft. (5/336ths of a house acre), and contained 250 plants.

The Manurial Treatment of each was as follows :—

Base Manure.—16 cwts. Straw Manure.

64 lbs. Bone Meal.

64 lbs. Bone Flour.

64 lbs. Hoof and Horn.

64 lbs. Sulphate of Potash.

125 lbs. Lime.

Top Dressing.—Mulch as stated.

1 cwt. of a Mixture of the following composition :—

6 parts Meat Meal.

8 parts Dissolved Bones.

3 parts Sulphate of Potash.

2 parts Bone Flour.

1 part Sulphate of Ammonia.

This gave 5% Ammonia, 24% Total Phosphates, 12% Soluble Phosphates and 7% Potash on examination.

Table IX.

Treatment.	Average Tons per Acre.				Relative.
	1920.	1921.	1922.	Average of three years.	
No Mulch ...	37.5	46.5	37.2	40.4	98
Dung Much ...	39.9	47.6	36.5	41.3	100
Straw Mulch ...	40.5	43.5	39.8	41.2	100

(b) Aeration Experiment.

This experiment was started in 1921, and repeated during the present season. The house was divided into three sections, M1, M2 (made up of two small plots), and M3. The aerating channels were rows of three inch unglazed pipes placed loosely together, to allow the air to pass out at the junctions. The rows of pipes were two-and-a-half feet apart and were embedded, in clinkers and fine cinders, fifteen inches below the soil surface. The general plan of the pipe systems is shown in Fig. 1. Sec-

tion M₁ was the control; in it the rows of pipes were blocked at each end. In Section M₂ the rows of pipes opened into a ditch at each end, one ditch being outside the house and one inside. Thus there was a free circulation of air in the pipes. In Section M₃ the rows of pipes were connected at the ends of the plot by means of T drain pipes cemented together. At one end a connection was made to a fan driven by a petrol engine. Air was drawn from the house to obviate the necessity of warming and moistening it, and was blown through the pipes during 15 minutes at 9 a.m. and 15 minutes at 4 p.m. each day. No attempt was made to determine the volume of air passed through the pipes in a given time, but the operator endeavoured to keep the engine running at a uniform rate throughout the experiment, so as to pass through the pipes approximately the same quantity of air each time. Kondine Red, the variety of tomato grown in 1921, was that planted. The aeration of the soil began on March 15th, a fortnight after planting; the experiment was continued until a week before the crop was cut out. Examination of the pipes at the end of the season showed them to be free from any obstruction. In 1921, the aerated section M₃ showed an increased yield of approximately 10%, and the open section M₂ an increase of 6% above M₁, the control section. The results obtained during the present season are given in Tables X.—XII.

The yield from the aerated section M₃ was approximately 6% higher than that of the control section M₁, whilst the open section M₂ gave no increase above the control. During the present season, the plants in this house suffered severely from Mosaic Disease; in this respect the plants in the aerated section showed no greater resistance than those in the other sections. Comparing the results during the two years of the experiment, it would appear that the aeration was most beneficial in the first season. This may be due to the fact that the soil, having been well broken up in the process of laying the pipes, was more easily aerated during the first year than during the second, when the soil had settled down into a less porous condition.

The mechanical difficulty of aerating the soil by artificial means may be the reason why the results were less satisfactory than was to be expected.

Table X:

M1. Control. Variety—"Kondine Red." House No. 5.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.88	.80	.02	.15	.20	2.05	14.90	36.87
B.	.35	.32	.09	.10	.18	1.04	7.56	18.65
C.	.43	.57	.35	.22	.21	1.78	12.94	31.95
D.	.19	.15	.10	.05	.10	.59	4.29	10.58
E.	.03	.01	—	—	—	.04	.29	.71
F.	.02	—	—	—	—	.02	.15	.36
G.	—	.02	—	.02	.01	.05	.36	.88
Total	1.90	1.87	.56	.54	.70	5.57	40.49	100

Table XI.

M2. Pipes open at both ends. Variety—"Kondine Red." House No. 5.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.76	.86	.08	.27	.23	2.20	15.75	38.77
B.	.25	.45	.08	.11	.21	1.10	7.87	19.36
C.	.40	.58	.31	.13	.19	1.61	11.52	28.31
D.	.22	.19	.11	.05	.13	.70	5.01	12.33
E.	.01	—	—	—	—	.01	.07	.17
F.	—	—	—	—	—	—	—	—
G.	—	.02	.01	.03	—	.06	.43	1.06
Total	1.64	2.10	.59	.59	.76	5.68	40.65	100

Table XII.

M3. Artificially Aerated. Variety "Kondine Red." House No. 5.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total	
A.	.90	.84	.08	.19	.19	2.20	16.00	37.27
B.	.36	.27	.06	.10	.20	0.99	7.20	16.78
C.	.49	.72	.24	.23	.24	1.92	13.96	32.54
D.	.23	.18	.11	.07	.10	.69	5.02	11.69
E.	.01	.02	—	—	—	.03	.22	.52
F.	—	—	—	—	—	—	—	—
G.	—	.06	—	.01	—	.07	.51	1.20
Total	1.99	2.09	.49	.60	.73	5.90	42.91	100

Plots M1, M2, and M3 were each $\frac{5}{252}$ nds of a house acre and contained 320 plants.

The Manurial Treatment of each was as follows:—

Base Manure.— $10\frac{2}{3}$ cwts. Straw Manure.
 43 lbs. Bone Meal.
 43 lbs. Bone Flour.
 43 lbs. Hoof and Horn.
 43 lbs. Sulphate of Potash.
 83 lbs. Lime.

Top Dressing.—Mulch of Straw Manure.
 75 lbs. of the same Mixed Fertiliser as used in G1—4
 and H1—4.

Manurial Experiments with Tomatoes.

The manurial trials, Series J and K in Houses 3 and 4, which previously had been conducted during 5 and 6 years respectively, were repeated. Perhaps the most striking result from this series this year is the great difference in yield of the variety "Comet" in comparison with "Kondine Red," grown under similar conditions. Thus, on the untreated plots, "Kondine Red" gave 5 tons per acre more fruit than "Comet," and nearly 14 tons per acre more than "Comet" on all the plots which received complete artificials and dung.

Complete artificials gave the highest yield in the "Comet" series, and complete artificials with dung the highest in the case of Kondine Red; complete artificials being second in the latter series. In both series the untreated plots gave the lowest yield. Complete artificials without potash held the third position in each series, whilst plots deficient in nitrogen and phosphates gave low yields.

The manurial trials have been in progress during six years in the case of Kondine Red and seven years in the case of Comet. Each plot has been similarly treated year after year; consequently the plots from which a particular nutrient has been withheld consistently may be considered to be starved in respect to this nutrient. This being so, it is time to begin constructive experiments, and next year's trials will be concerned with building up the starved plots, with the ultimate object of determining the composition of a fertiliser mixture best suited to the tomato crop.

In the Seventh Annual Report, attention was first drawn to the relation of manurial treatment to the incidence of the disorder known as "waxy-patch," "Green patch," etc. This is typically a form of blotchy irregular ripening of tomato fruits in which parts of the fruit never ripen properly. During 1921, it was found that the plots deficient in nitrogen and potash yielded a large proportion of this kind of fruit. Similar results were forthcoming during the present season, when Kondine Red, which is highly susceptible to this trouble, showed 38.65% blotchy fruit on the untreated plot; 7.15% on the plot receiving phosphates and potash but no nitrogen; and 20.15% on the plot receiving phosphates and nitrogen without potash. All other plots in the Kondine Red series, with one exception, gave less than 1% blotchy fruit. In the case of Comet, the untreated plot gave 8.64% blotchy fruits, complete artificials without potash gave 1.52%, while three other plots showed less than 0.3%, and the remaining three gave no blotchy fruits.

Thus the present year's results confirm those of 1921 as follows:—

(A) The variety Kondine Red is more susceptible to the disorder than Comet.

(B) A deficiency of potash in the soil increases susceptibility to the disorder.

(C) A deficiency of nitrogen in the soil is also a determining factor which probably varies with the kind of season, being most important in hot dry seasons.

The results of the tomato manurial trials are tabulated fully in Tables XIII.—XXIX.

Table XIII.

J1. Double Complete Artificial. Variety—"Comet." House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June	July	Aug.	Sept.	Oct.	Total.	Total.	
A.	.43	.87	.43	.11	.37	2.21	17.53	55.64
B.	.11	.13	.05	.02	.11	.42	3.34	10.57
C.	.14	.35	.16	.06	.19	.90	7.14	22.67
D.	.11	.08	.05	.02	.08	.34	2.70	8.57
E.	—	—	—	—	—	—	—	—
F.	.01	—	—	—	—	.01	.08	.26
G.	—	.02	.02	.05	—	.09	.72	2.29
Total	.80	1.45	.71	.26	.75	3.97	31.51	100

Table XIV.

J2. Untreated. Variety—"Comet." House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.47	.86	.17	.10	.21	1.86	14.75	57.40
B.	.08	.03	.01	.06	.07	.25	1.98	7.70
C.	.20	.21	.07	.04	.10	.62	4.92	19.14
D.	.04	.09	.03	.02	.04	.22	1.75	6.81
E.	.03	.11	.13	.01	—	.28	2.22	8.64
F.	.01	—	—	—	—	.01	.08	.31
G.	—	—	—	—	—	—	—	—
Total	.83	1.30	.41	.23	.47	3.24	25.70	100

Table XV.

J3. Standard and Complete Artificialics.

Variety—"Comet."

House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.53	.82	.28	.11	.13	1.87	14.83	49.79
B.	.16	.08	.02	.02	.07	.35	2.78	9.33
C.	.21	.29	.23	.10	.19	1.02	8.04	27.00
D.	.11	.09	.11	.04	.04	.39	3.10	10.41
F.	—	.01	—	—	—	.01	.08	.27
E.	.01	—	—	—	—	.01	.08	.27
G.	—	.01	.03	.07	—	.11	.87	2.92
Total	1.02	1.30	.67	.34	.43	3.76	29.78	100

Table XVI.

J4. Complete Artificialics Plus Dung.

Variety—"Comet."

House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.66	.64	.23	.07	.27	1.87	14.83	50.24
B.	.15	.12	.04	.03	.04	.38	3.00	10.16
C.	.17	.27	.17	.08	.33	1.02	8.04	27.24
D.	.12	.16	.06	.03	.06	.43	3.41	11.55
E.	.01	—	—	—	—	.01	.08	.27
F.	.01	—	—	—	—	.01	.08	.27
G.	—	—	.01	—	—	.01	.08	.27
Total	1.12	1.19	.51	.21	.70	3.73	29.52	100

Table XVII.

J5. Complete Artificial. Variety—"Comet." House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.70	1.03	.38	.09	.20	2.40	18.93	57.98
B.	.17	.08	.04	.03	.07	.39	3.10	9.50
C.	.22	.27	.15	.10	.20	.94	7.46	22.84
D.	.09	.15	.07	.02	.05	.38	3.00	9.19
E.	—	—	—	—	—	—	—	—
F.	—	—	—	—	—	—	—	—
G.	.01	—	—	.01	—	.02	.16	.49
Total	1.19	1.53	.64	.25	.52	4.13	32.65	100

Table XVIII.

J6. Complete Artificial Less Phosphates.
Variety—"Comet." House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.69	.84	.31	.05	.17	2.06	16.34	53.46
B.	.19	.13	.04	.03	.10	.49	3.89	12.73
C.	.24	.20	.19	.11	.22	.96	7.61	24.91
D.	.12	.13	.05	.02	.01	.33	2.64	8.64
E.	—	—	—	—	—	—	—	—
F.	.01	—	—	—	—	.01	.08	.26
G.	—	—	—	—	—	—	—	—
Total	1.25	1.30	.59	.21	.50	3.85	30.55	100

Table XIX.

J7. Complete Artificial Less Nitrogen.

Variety—"Comet."

House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.69	.67	.24	.13	.13	1.86	14.75	53.59
B.	.17	.09	.07	.07	.12	.52	4.12	14.97
C.	.32	.15	.11	.06	.12	.76	6.03	21.93
D.	.09	.11	.06	.02	.04	.32	2.54	9.23
E.	.01	—	—	—	—	.01	.08	.28
F.	—	—	—	—	—	—	—	—
G.	—	—	—	—	—	—	—	—
Total	1.28	1.02	.48	.28	.41	3.47	27.52	100

Table XX.

J8. Complete Artificial Less Potash.

Variety—"Comet."

House No. 3.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.52	.54	.30	.10	.15	1.61	12.76	40.63
B.	.15	.07	.05	.02	.06	.35	2.78	8.85
C.	.42	.36	.22	.22	.26	1.48	11.74	37.39
D.	.11	.12	.05	.04	.02	.34	2.70	8.59
E.	.04	—	.02	—	—	.06	.48	1.52
F.	—	—	—	—	—	—	—	—
G.	—	—	.05	.05	.02	.12	.95	3.02
Total	1.24	1.09	.69	.43	.51	3.96	31.41	100

Table XXI.

K1. Double Complete Artificials.

Variety—"Kondine Red."

House. No 4.

Grade.	Lbs. per Plant.						Tons per Acre	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.72	.58	.12	.30	.25	1.97	15.63	38.60
B.	.27	.39	.09	.15	.28	1.18	9.37	23.15
C.	.29	.39	.07	.13	.21	1.09	8.65	21.37
D.	.24	.32	.11	.03	.09	.79	6.27	15.49
E.	.03	.02	—	—	—	.05	.40	.99
F.	.01	.01	—	—	—	.02	.16	.40
G.	—	—	—	—	—	—	—	—
Total	1.56	1.71	.39	.61	.83	5.10	40.48	100

Table XXII.

K2. Untreated.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.41	.31	.02	.02	.05	.81	6.42	20.86
B.	.13	.08	.01	.01	.13	.36	2.86	9.30
C.	.28	.20	.02	.05	.15	.70	5.55	18.03
D.	.16	.18	.05	.03	.05	.47	3.73	12.12
E.	.48	.38	.20	.22	.22	1.50	11.89	38.65
F.	.02	—	—	.01	—	.03	.24	.78
G.	—	.01	—	—	—	.01	.08	.26
Total	1.48	1.16	.30	.34	.60	3.88	30.77	100

Table XXIII.

K3. Standard Treatment and Complete Artificial.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	1.10	.46	.09	.18	.20	2.03	16.10	38.82
B.	.33	.29	.09	.11	.19	1.01	8.01	19.32
C.	.38	.38	.13	.13	.27	1.29	10.23	24.66
D.	.21	.27	.14	.04	.12	.78	6.19	14.92
E.	.01	.07	.02	—	—	.10	.79	1.90
F.	—	—	—	—	—	—	—	—
G.	—	—	—	.02	—	.02	.16	.38
Total	2.03	1.47	.47	.48	.78	5.23	41.48	100

Table XXIV.

K4. Complete Artificial Plus Dung.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.93	.96	.07	.15	.24	2.35	18.63	43.01
B.	.38	.33	.06	.09	.22	1.08	8.57	19.79
C.	.31	.47	.15	.12	.28	1.33	10.55	24.38
D.	.21	.20	.09	.05	.09	.64	5.08	11.72
E.	.01	—	.03	.01	—	.05	.40	.92
F.	—	—	—	—	—	—	—	—
G.	—	—	—	.01	—	.01	.08	.18
Total	1.84	1.96	.40	.43	.83	5.46	43.31	100

Table XXV.

K5. Complete Artificial.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	1.05	1.19	.08	.16	.26	2.74	21.75	50.44
B.	.39	.25	.05	.11	.19	.99	7.88	18.27
C.	.31	.34	.08	.12	.21	1.06	8.42	19.53
D.	.21	.21	.06	.03	.10	.61	4.83	11.20
E.	.02	—	—	—	—	.02	.16	.37
F.	—	—	—	—	—	—	—	—
G.	—	—	—	.01	—	.01	.08	.19
Total	1.98	1.99	.27	.43	.76	5.43	43.12	100

Table XXVI.

K6. Complete Artificial Less Phosphates.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	1.05	1.04	.08	.19	.16	2.52	20.01	52.38
B.	.30	.25	.05	.10	.24	.94	7.47	19.55
C.	.25	.26	.06	.06	.17	.80	6.35	16.63
D.	.21	.14	.05	.02	.09	.51	4.05	10.60
E.	.01	—	—	—	—	.01	.08	.21
F.	.01	—	—	—	—	.01	.08	.21
G.	—	—	.01	.01	—	.02	.16	.42
Total	1.83	1.69	.25	.38	.66	4.81	38.20	100

Table XXVII.

K7. Complete Artificial Less Nitrogen.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	1.36	.51	.06	.12	.11	2.16	17.15	42.86
B.	.39	.14	.06	.13	.24	.96	7.63	19.06
C.	.48	.21	.10	.05	.17	1.01	8.01	20.01
D.	.24	.13	.08	.02	.07	.54	4.29	10.72
E.	.01	.27	.03	.03	.02	.36	2.86	7.15
F.	—	—	—	—	—	—	—	—
G.	—	—	—	—	.01	.01	.08	.20
Total	2.48	1.26	.33	.35	.62	5.04	40.02	100

Table XXVIII.

K8. Complete Artificial Less Potash.

Variety—"Kondine Red."

House No. 4.

Grade.	Lbs. per Plant.						Tons per Acre.	Per Cent. of Total.
	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	
A.	.92	.59	.03	.03	.21	1.78	14.14	33.52
B.	.22	.09	.03	.04	.18	.56	4.44	10.53
C.	.47	.28	.09	.08	.27	1.19	9.46	22.43
D.	.24	.14	.09	.04	.12	.63	5.00	11.85
E.	.43	.42	.07	.15	—	1.07	8.50	20.15
F.	.01	—	—	—	—	.01	.08	.19
G.	—	.04	—	.01	.02	.07	.56	1.33
Total	2.29	1.56	.31	.35	.80	5.31	42.18	100

The individual Plots in J and K are each 22 ft. 8 in. by 13 ft., 1/148th of an house acre, and contain 120 plants.

The Manurial Treatment is as follows :—

J1 and K1—Double complete artificials, *i.e.*, double the treatment in J5 and K5.

J2 and K2—Untreated control plots.

J3 and K3—Standard plus complete artificials equivalent in nutritive value to half the standard.

Before Planting—Standard winter dressing consisting of 14 lbs. of straw manure, 9.5 lbs. bone meal, 0.5 lb. bone flour, 0.5 lb. ground hoofs, 0.5 lb. sulphate of potash, and 0.4 lb. of basic slag per square yard.

After Planting, in four equal instalments—0.2 lb. sulphate of ammonia, 0.2 lb. nitrate of soda, 0.5 lb. superphosphate, and 0.2 lb. sulphate of potash per square yard.

J4 and K4—Complete artificials plus dung.

Before Planting—7 lbs. straw manure, 0.4 lb. basic slag, and 0.1 lb. sulphate of potash per square yard.

After Planting, in four equal instalments—0.2 lb. sulphate of ammonia, 0.2 lb. nitrate of soda, 0.5 lb. superphosphate, and 0.2 lb. sulphate of potash per square yard.

J5 and K5—Complete artificials only.

The same as in plots J4 and K4 with the omission of straw manure.

J6 and K6—Complete artificials less phosphates.

The same as in plots J4 and K4 omitting straw manure, slag and superphosphate.

J7 and K7—Complete artificials less nitrogen.

The same as in plots J4 and K4 omitting straw manure, sulphate of ammonia and nitrate of soda.

J8 and K8—Complete artificials less potash.

The same as in plots J4 and K4 omitting straw manure and sulphate of potash.

Table XXIX.

Crops in lbs. per plant grown on plots (22 ft. 8 ins. by 13 ft.) containing 120 plants and occupying 1/148th of a house acre.

Plot Number and Treatment.	Series J. Variety—"Comet."						Series K. Variety—"Kondine Red."						Mean of two Series.			
	Lbs. during					Total. Lbs. per plant. Tons per acre.	Lbs. during					Total. Lbs. per plant. Tons per acre.		Relative.		
	June.	July.	August.	Sept.	Oct.		June.	July.	August.	Sept.	Oct.					
5. Complete Artificial.	1.19	1.53	0.64	0.25	0.52	4.13	32.7	100	1.98	1.99	0.27	0.43	0.76	5.43	43.1	100
6. Complete Artificial less Phosphates ...	1.25	1.30	0.59	0.21	0.50	3.85	30.6	94	1.83	1.69	0.25	0.38	0.66	4.81	38.2	89
7. Complete Artificial less Nitrogen ...	1.28	1.02	0.48	0.28	0.41	3.47	27.5	84	2.48	1.26	0.33	0.35	0.62	5.04	40.0	93
8. Complete Artificial less Potash ...	1.24	1.09	0.69	0.43	0.51	3.96	31.4	96	2.29	1.56	0.31	0.35	0.80	5.31	42.2	97
4. Complete Artificial plus Dung ...	1.12	1.19	0.51	0.21	0.70	3.73	29.5	90	1.84	1.96	0.40	0.43	0.83	5.46	43.3	101
3. Standard Treatment plus C.A. ...	1.02	1.30	0.67	0.34	0.43	3.76	29.8	91	2.03	1.47	0.47	0.48	0.78	5.23	41.5	96
2. Untreated Control Plot ...	0.83	1.30	0.41	0.23	0.47	3.24	25.7	79	1.48	1.16	0.30	0.34	0.60	3.88	30.8	71
1. Double Complete Artificial ...	0.80	1.45	0.71	0.26	0.75	3.97	31.5	96	1.56	1.71	0.39	0.61	0.83	5.10	40.5	94

Cucumber Experiments.

(a) Base Treatment.

Bad effects have frequently been noticed in commercial cucumber houses, when the roots of the plants enter the base or soil upon which the borders are placed. In bad cases the leaves develop yellow patches, which soon wither and die: the laterals become weak and stunted: the young fruits grow slowly and in many cases do not reach maturity; and the total yield per acre is reduced accordingly. The different influences in the base, causing these bad effects, have not been ascertained; they will be the object of later investigations.

Meanwhile a series of experiments was arranged to test the effects of different base treatments in Houses D and E. One side of each house was allotted to each treatment but in calculating the results, the northern quarter of each plot was omitted as it was previously shown that this portion of the houses is adversely affected by shade from the laboratories.

The base of plot D1 was thoroughly steamed, to destroy the possible harmful agents present. This was done by the inverted tray system. The base was thoroughly broken up and zinc-lined, wooden trays, 9ft. by $2\frac{1}{2}$ ft. by 5 inches, were inverted on the border; the sides were pressed into the soil and tightly packed with soil from the neighbourhood of the wall and path. Waterproof sheets were then laid over the top. Steam at 60 lbs. pressure was introduced through pipes laid under the trays, four trays being used at a time and steam passed during $1\frac{1}{2}$ hours. Half-an-hour after removing the trays the following temperatures were ascertained:—

210°F.	at a depth of 3 inches below the surface.								
200°F.	„ „ „ „ 6	„	„	„	„	„	„	„	„
190°F.	„ „ „ „ 9	„	„	„	„	„	„	„	„
150°F.	„ „ „ „ 15	„	„	„	„	„	„	„	„

It was found, however, that this process did not raise the temperature of the soil at the sides of the border sufficiently high; a special method of treating these parts, devised by Mr. C. H. Shoults, was therefore adopted. Galvanised iron covers 8ft. long were bent, so that the ends formed a half circle some 20 inches in diameter; these were placed at the back of the border and also in front by the side of the path; they were firmly embedded, covered with sacks and sheets like the trays, and steam passed beneath for 1 hour. The following temperatures were noted half-an-hour after removing the covers:—

210°F.	at a depth of 3 inches below the soil surface.								
190°F.	„ „ „ „ 9	„	„	„	„	„	„	„	„
150°F.	„ „ „ „ 15	„	„	„	„	„	„	„	„
130°F.	„ „ „ „ 18	„	„	„	„	„	„	„	„

The steaming was done on January 25th and 26th. In the case of plots D2 and E1, which are the adjoining plots of two adjacent houses D and E, the base was covered with a layer of concrete, to prevent the roots of the plant from entering it. During the season any roots growing towards the edge of the concrete base were severed. The soil was first dug and built up so that the surface was sloped in the correct manner, being highest where the two plots met and lowest near the paths of the two houses. The soil was then beaten hard and covered with a two to three inch layer of concrete, which was finally faced with cement to give a clean smooth finish. In plot D2 a three inch layer of ashes was placed over the concrete, while in plot E1 no ashes were employed. In plot E2 the control, the base was dug and flooded as usual, but no other treatment was given.

The beds were uniform throughout the four plots, being made up of one part stable manure and two parts loam, together with a sprinkling of lime. The compost was prepared in November and used through the season for purposes of top dressing. During the season a dressing of the fertiliser used in tomato series G.H. and M. was given when the plants required it. Details are given in Table XXX. The results of the experiment are set out in Table XXXI.

Table XXX.

Showing the composition of the beds and the top-dressing treatments employed in the cucumber experiments.

House.	Beds.	Top Dressing.		
		1st ten dressings March to May.	2nd ten dressings May to July.	Four dressings July to October.
D.	2 parts loam 1 part dung composted in November.	Loam and dung.	Loam and dung.	Loam and dung with 4 lbs. of fertiliser as given in Tomato Series G, H. and M. to every 100 feet of border.
E.	2 parts loam 1 part dung composted in November.	Loam and dung.	Loam and dung.	Loam and dung with 4 lbs. of fertiliser as given in Tomato Series G, H. and M. to every 100 feet of border.
F.	As in D. and E. with 1 lb. superphosphate to every 10 feet of border.	As in D. and E. with 2 lbs. superphosphate to every 100 feet of border.	As in D. and E. with 3 lbs. superphosphate to every 100 feet of border.	Loam and dung with 4 lbs. of fertiliser as given in Tomato Series G, H. and M. to every 100 feet of border.

Table XXXI.

Plants grown borders (75 ft. by 3 ft.) containing 38 plants and occupying 5/447ths of a house acre.

Plot.	Base Treatment.	Lbs. per Plant.	Tons per Acre.	Flats per Foot.	Relative Values.
D1.	Base steamed.	67.5	101.93	1.9	136
D2.	Base covered with concrete on which was placed a three-inch layer of ashes.	48.6	73.39	1.4	100
E1.	Base covered with a layer of concrete.	52.9	79.88	1.5	107
E2.	Control. No base treatment.	49.9	75.35	1.4	100

It will be seen that steaming the base led to an increase of 35% above the control plot. Plots D2 and E1, where the base was covered with a layer of concrete, gave practically no increase above the control; but this may be due in part to the limited root space in the beds—a problem which will be investigated during 1923.

During the early part of the season, the difference between the plants grown over the steamed base and those on the other plots was most marked. The former grew more rapidly and were larger and more vigorous plants than the latter. The advantage of steaming the base needs no further comment.

(b) Pollination Experiments.

During an investigation of Anthracnose of the cucumber due to *Colletotrichum oligochaetum* indications were obtained that plants bearing seed fruit were more resistant to this disease than those bearing the usual unfertilised fruits. Similar indications have been found in relation to attacks of Red Spider. An experiment was arranged and conducted in cucumber house F during the past season for the purpose of confirming such observations. On plot F1 cucumbers were grown in the normal way, whilst on plot F2 the female flowers were pollinated, so that one seed fruit was always present on each plant. Throughout the season each plant bore three such fruits, the rest being the normal unfertilised type. When the first seed fruit was showing signs of maturity, a second was pollinated, and the

first was not removed until the second showed signs of seed formation by becoming swollen at the blossom end. The manurial treatment of the plots is given in Table XXX. Normal fruits and seed fruits were weighed separately and the results are given in Table XXXII.

Table XXXII.

Plants grown in borders (75 ft. by 3 ft.) containing 38 plants and occupying 5/447ths of a house acre.

Plot.	Treatment.	Type of Fruit.	Lbs. per Plant.	Tons per Acre.	Flats per Foot.
F1.	Control.	Normal Fruits.	52.2	78.8	1.5
F2.	One Seed Fruit per Plant.	Normal Fruits.	44.9	67.8	1.2
		Seed Fruits.	5.6	8.46	0.2

The results show that when a cucumber plant bears a number of seed fruits, the weight of normal fruit possessing a commercial value is reduced as a consequence. The total weight of seed fruit and normal fruit obtained from F2 approximates to the weight of normal fruit obtained from F1. The experiment did not prove that the presence of seed fruit made the plants more resistant to the "leaf spot" disease or to the Red Spider. This was due mainly to the fact that the plants were practically free from the latter, and completely so from the former; under the existing conditions it was undesirable to introduce the organisms.

Reference must be made to the comparative freedom from Red Spider in the houses. It is felt that this is due in no small measure to the result of cleansing the houses with an emulsion of Cresylic acid and soft soap as recommended by Dr. Ll. Lloyd during the winter of 1921-22. Until the end of July the houses were free from Red Spider, but early in August an invasion occurred at the door end of the centre house, the pest having come from a neighbouring hedge, which was badly infected. The invasion was checked by spraying with Liver of Sulphur and flour paste combined with correct methods of cultivation; at no time were the plants badly attacked.

Soil Sterilisation Experiments.

Sterilisation experiments in trade nurseries were continued in the same houses and on the same plots as in the three previous years. In Tables XXXIII.-XXXIV. this season's results are compared with those of 1919, 1920, and 1921.

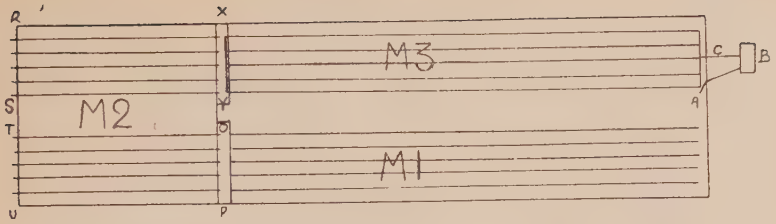
Table XXIII.
Soil Sterilisation Experiments. Nursery No. 1.

TREATMENT.	Yield per plant 1922.						Total 1922.			1921.			1920.			1919.			Average lbs. per plant.	Average tons per acre.	Relative.
	Plot No.	June.	July.	Aug.	Sept.	Oct.	Lbs. per plant.	Tons pr. Acre.	Relative.	Lbs. per plant.	Tons pr. Acre.	Relative.	Lbs. per plant.	Tons pr. Acre.	Relative.	Lbs. per plant.	Tons pr. Acre.	Relative.			
House A.	1	0.56	1.75	0.75	0.49	0.43	3.98	31.8	124	4.01	32.1	104	3.99	31.9	100	4.29	34.3	114	4.07	32.5	110
	5	0.82	1.71	0.85	0.46	0.46	4.30	34.4	134	4.70	37.6	122	4.06	32.4	101	4.44	35.5	118	4.38	35.0	118
	6	0.93	1.64	0.72	0.45	0.52	4.26	34.1	133	5.07	40.6	132	4.48	35.8	112	4.44	35.5	118	4.56	36.5	123
	8	0.61	1.44	0.41	0.54	0.46	3.46	27.7	108	4.43	35.4	115	3.66	29.2	91	4.36	34.9	116	3.98	31.8	107
	3	0.90	1.64	0.66	0.43	0.44	4.07	32.6	127	4.82	38.6	125	4.55	36.4	114	4.43	35.4	118	4.47	35.8	121
	7	0.76	1.77	0.63	0.51	0.53	4.20	33.6	131	4.71	37.7	122	3.72	29.7	93	4.44	35.5	116	4.27	34.1	115
	2	0.81	1.30	0.57	0.39	0.41	3.48	27.8	109	4.02	32.2	104	4.12	32.9	103	3.87	31.0	103	3.87	31.0	105
	4	0.71	1.06	0.46	0.33	0.37	2.93	23.4	91	3.68	29.4	96	3.89	31.1	97	3.64	29.1	97	3.54	28.3	95
House B.	2	0.90	2.19	0.74	0.37	1.36	5.56	44.5	152	5.04	40.3	130	3.89	31.1	118	4.77	38.2	131	4.82	38.5	133
	6	0.92	1.84	0.91	0.38	1.43	5.48	43.8	149	4.81	39.3	127	3.73	29.8	114	4.51	36.1	124	4.63	37.3	129
	5	0.68	1.27	0.63	0.25	1.10	3.93	31.4	107	4.38	35.0	113	3.25	28.0	107	4.15	33.2	114	3.78	31.9	110
	8	0.71	1.42	0.55	0.30	1.22	4.20	33.6	115	4.03	32.2	104	3.27	26.2	100	4.03	34.2	118	3.89	31.6	109
	4	0.63	1.39	0.58	0.24	0.97	3.81	30.5	104	3.99	31.9	103	3.40	27.2	104	3.70	29.6	102	3.73	29.8	103
	7	0.84	1.47	0.53	0.29	1.20	4.33	34.6	108	4.38	35.0	113	3.61	28.9	110	4.18	33.4	115	4.13	33.0	114
	1	0.68	1.30	0.36	0.34	0.90	3.58	28.6	98	3.92	31.3	101	3.10	24.8	95	3.57	28.6	98	3.54	28.3	98
	3	0.79	1.30	0.47	0.29	0.93	3.78	30.0	102	3.81	30.5	98	3.46	27.7	105	3.70	29.6	102	3.69	29.5	102

Table XXIV.
Soil Sterilisation Experiments. Nursery No. 2.

TREATMENT.	Yield per plant 1922.						Total 1922.			1921.			1920.			1919.			Average lbs. per plant.	Average tons per acre.	Relative.				
	Plot No.	June.	July.	Aug.	Sept.	Oct.	Lbs. per plant.	Tons pr acre.	Relative.	Lbs. per plant.	Tons pr acre.	Relative.	Lbs. per plant.	Tons pr acre.	Relative.	Lbs. per plant.	Tons pr acre.	Relative.							
House A.	Untreated	3	1.95	1.21	0.50	0.55	0.38	4.59	36.7	103	100	103	100	4.90	39.2	103	100	5.29	42.3	99	100	4.84	38.7	102	100
	Untreated	...	7	1.91	1.05	0.44	0.53	0.39	4.32	34.6	97	97	97	4.64	37.1	97	101	5.41	43.3	101	101	4.67	37.4	98	98
	Carbolic ...	...	2	2.23	1.00	0.40	0.52	0.38	4.53	32.2	90	98	100	4.99	39.9	105	104	5.16	41.3	96	97	4.79	37.3	98	98
	Carbolic ...	...	6	1.92	0.98	0.46	0.56	0.32	4.24	33.9	95	95	95	4.86	38.9	102	97	5.20	41.6	97	97	4.63	37.0	97	97
	Steam ...	...	1	2.46	1.29	0.47	0.61	0.49	5.32	42.6	119	113	120	5.31	41.0	107	100	5.39	43.1	101	103	5.29	42.3	111	107
	Steam ...	...	5	2.26	1.13	0.51	0.53	0.33	4.76	38.1	107	107	107	4.75	38.0	93	105	5.63	45.0	105	105	4.89	39.1	103	103
House B.	Hot Water	...	4	2.07	1.19	0.46	0.53	0.37	4.62	37.0	104	111	104	4.62	37.0	101	109	5.76	46.1	108	105	4.95	39.7	104	115
	Hot Water	...	8	2.36	1.31	0.50	0.60	0.44	5.21	41.7	117	111	117	5.20	41.6	116	102	5.43	43.4	102	102	5.35	42.8	126	126
	Untreated	...	1	1.95	1.33	0.49	0.60	0.65	5.02	40.2	106	100	105	5.03	40.2	108	97	5.47	43.8	97	100	5.18	41.5	104	100
	Untreated	...	5	1.64	1.25	0.49	0.56	0.50	4.44	35.5	94	95	95	4.52	36.2	92	103	5.78	46.2	103	100	4.81	38.4	96	96
	Carbolic ...	...	4	2.13	1.32	0.47	0.55	0.47	4.94	39.5	104	106	104	4.97	39.8	95	103	5.49	43.9	98	97	5.01	40.0	100	103
	Carbolic ...	...	8	2.28	1.05	0.45	0.61	0.65	5.04	40.3	107	105	105	5.00	40.0	111	96	5.37	43.9	96	97	5.20	41.9	105	105
	Steam ...	...	3	1.95	0.92	0.42	0.61	0.35	4.25	34.0	90	95	89	4.23	33.8	86	90	5.29	42.3	94	95	4.49	35.9	90	94
	Steam ...	...	7	2.26	1.05	0.44	0.53	0.55	4.83	38.6	102	100	100	4.78	38.2	93	95	5.34	42.7	95	95	4.87	38.9	97	97
	Hot Water	...	2	1.82	1.05	0.42	0.56	0.58	4.43	35.4	93	94	94	4.48	35.8	107	104	5.42	43.4	96	94	4.88	39.1	98	97
	Hot Water	...	6	1.99	1.03	0.42	0.53	0.50	4.47	35.8	95	93	93	4.46	35.7	101	91	5.12	41.0	91	91	4.74	37.9	95	95

Fig. 1.



- A - Pipe collecting heated air from the house
 B - Petrol engine and fan
 C - Pipe through which air is blown into the aerating system
 X, Y, O, P, R, S, T, U, = Ditches 1 foot wide and 2 feet deep

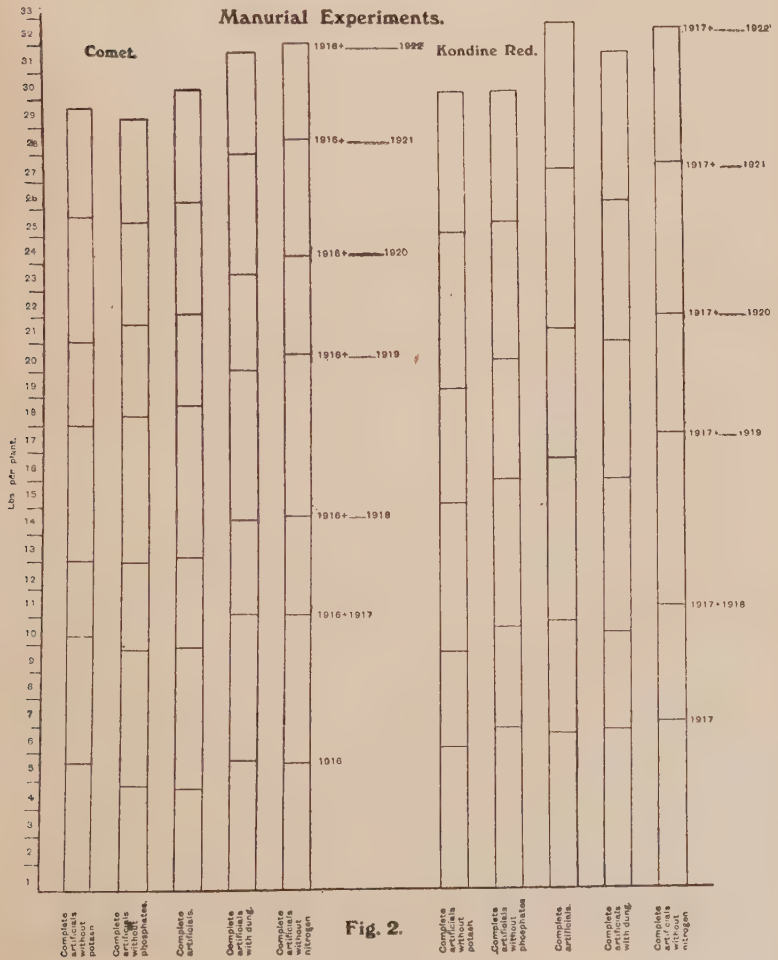


Fig. 2.

Mycological Report.

During the past year Mosaic disease of the tomato and cucumber have constituted the main object of research, but the new tomato root rot reported last year and stem rot of the tomato also received attention.

Several diseases not previously reported are noted below.

<i>Host.</i>	<i>Disease.</i>	<i>Parasite.</i>
Chrysanthemum	Rust	<i>Puccinia chrysanthemi</i>
Cucumber	Powdery mildew	<i>Erysiphe polygoni</i>
Rose	" "	<i>Sphaerotheca pannosa</i>
Rose	Bronzing	Cause unknown
Tomato	Dropsy or oedema	Physiological cause
Ivy leaved geranium	" " "	" " "
Narcissus	Bulb rot	<i>Botrytis sp</i>
Ash	Mosaic disease	Cause unknown
Black nightshade	" "	" "
Petunia	" "	" "
Potato	" "	" "
Tobacco	" "	" "
Passion flower	" "	" "

A new Root Disease of the Tomato.

This disease was first noticed on tomato roots obtained from a commercial nursery in 1919, but at that time it was not possible to study it further. In 1921 the disease was frequently found on roots of wilted plants and investigations were then begun. Observations made in the district have indicated that the disease is of greater gravity than was at first thought. Most tomato soils have been found to be infected, if tomatoes have been grown for any length of time.

Symptoms of the Disease.

Affected plants cease to develop in a normal manner; the lowest leaves turn yellow and die prematurely, while any new growth is weak and pale in colour. In advanced stages, the stem becomes hollow and yellow, a dark brown discoloration sometimes appearing on the outside of the stem near the ground and spreading rapidly up the plant. Usually the discoloured streak is about a quarter of an inch in width, and occurs only on one side of the stem. The disorder known as "hollow stem" is frequently associated with the presence of this disease at the roots. In final stages all the leaves wither and the plant dies. On attempting to uproot a diseased plant, the roots offer no resistance, as they are dry and shrivelled, and the decayed base separates readily from the soil. When the roots are carefully dug out, they are seen to be completely decayed and brown. The tissues external to the wood are dry and shrivelled, fitting loosely over the central woody cylinder.

The distinctive feature of the disease is the presence of innumerable minute globular black sclerotia both external to and embedded in the wood. Generally these are confined to the roots; in bad cases the base of the stem and even the lower portion of the aerial parts may contain sclerotia.

The infected wood is brown in colour, being generally of a darker shade than that infected by *Verticillium albo-atrum* or *Fusarium lycopersici*.

The Causal Organism.

The causal organism, *Sclerotium setosum*, Bewley and Shearn, was easily isolated by transferring a small piece of diseased wood to a tube of nutrient medium.

The fungal filaments produce comparatively few conidia on short branches and numerous black sclerotia. The sclerotia are very small, being approximately $1/200$ th of an inch in diameter. When a sclerotium is taken from the outside of a diseased root and examined under the microscope a number of black spines or setæ are seen on the surface. These are approximately half as long as the diameter of the sclerotium.

The fungus enters the plant through the roots, and while it is assisted by wounds, the latter do not appear essential for infection. The finer roots are first attacked, and the fungus spreads rapidly through the tissues to the stem base and even into the aerial portions, where it has been found up to 32 inches above the ground level. Sclerotia are produced within the larger wood vessels as well as in the pith cavity and on the outside of the wood. Those within the tissues rarely develop setæ, and are irregular in shape as they accommodate themselves to the shape of the cells.

Inoculation Experiments.

The pathogenicity of the isolated organism was readily proved by planting healthy plants in sterilised soil copiously inoculated with sclerotia obtained from a pure culture. The lower leaves of such plants became yellow and drooped within six weeks of planting while those of suitable controls remained green and turgid. Within three months of planting, ten plants out of twelve were completely stunted in comparison with the healthy controls. The roots of all twelve plants were in an advanced state of decay, shewing typical sclerotia, and the parasite was readily re-isolated. The roots of the control plant were quite healthy. Attempts were made to infect plants by inoculations above ground, but without success; on the other hand, root inoculations were entirely successful. Tomato fruits, both green and red, were rapidly rotted by the fungus.

In view of these results, it would appear that the disease is contracted in the soil, and that infection of the aerial portion rarely, if ever, occurs.

Control of the Disease.

No successful control measures have yet been discovered, but the investigation of this part of the problem is in progress. Facts are available which point to the probable introduction of the disease in straw manure. The parasite grows readily upon moist straw, and cultures on straw manure have yielded good growth under laboratory conditions.

Further, an examination of tomato roots from plots at the Experimental Station has shewn that where no stable manure has been given for five years the roots were free from the parasite, while plots receiving annual dressings of stable manure produced plants whose roots were badly diseased.

Botrytis Stem Rot of the Tomato.

This disease, which is common in most nurseries, is by no means a new one, but in view of the fact that it is responsible for a considerable amount of damage and that simple control means are available it seems desirable to discuss the question here.

Typical symptoms are the appearance of grey or greyish brown, slightly sunken, smooth patches extending up the stem and girdling it in the neighbourhood of leaf or truss bases.

In moist atmospheres the diseased portion becomes covered with a luxuriant grey mould, the spore-bearing filaments of the parasite *Botrytis sp.* The spores are readily blown about the house as the workers can testify, and, provided the conditions are suitable, the disease spreads rapidly.

Infection takes place through jagged, badly-pruned, half-dead leaf bases, broken tissues and incorrectly pruned leaves. The spores settle on these wounds, germinate and live on the half-dead tissues. The fungus thus gains virulence and spreads into the living tissues, where it makes rapid progress. On sectioning an infected portion of the stem, it is seen that the fungus attacks the cortex, vascular tissues and pith, producing a brown discoloration. The fungus travels quickly in the vascular system and in advanced stages of the disease, the browning in the vessels has been traced as far as seventeen inches above and below the point of infection.

Under suitable conditions the fungus spreads rapidly through the stem, severing all connection between the healthy parts of the plant above and below the affected area, thus causing the death of all parts above the lesion. Leaves and fruits are also attacked, and being excellent media for spore production, become a dangerous source of infection to the stems.

Control Measures.

Warm, moist conditions of the atmosphere surrounding the plants accompanied by insufficient ventilation and imperfect circulation of the air, by reason of dense foliage, are most suited to spore production and the rapid spread of the disease. Also soft sappy plants are more susceptible to the disease than those of a tougher nature—a fact which is emphasised by the prevalence of this disease on land sterilised by steam, and which has been manured too liberally with nitrogenous manures. The spores of this fungus are universally present in the air, and any attempt to exclude this natural infection must meet with failure; but under glasshouse conditions there are other sources which increase the quantity of infection, and these must be eliminated. Thus, if allowed to lie on the soil, damaged fruits are frequently infected with *Botrytis*, and become covered with a mass of spore-bearing fungal filaments. String used during the previous season and which has not been sterilised may also carry the disease to the following season.

Observation and experiment has shewn that when the leaves are carelessly removed, leaving a jagged base, this latter is readily infected, while clean-cut leaf bases, severed close to the stem, readily heal and are not infected. So marked is the effect that it is possible to find in many nurseries plants infected at the jagged leaf bases, but healthy where the leaves have been carefully cut away in the proper manner. Again, during the season it is often necessary to cut away half a leaf to allow the air and light to reach the fruits. When this is done, the pruning cut should be made close to a leaflet, as it will then heal up readily. If the cut is made so that an inch or more of bare stalk remains beyond a leaflet, this bare piece will die and usually becomes infected by *Botrytis*, which thus gains admittance to healthy tissues, and, passing down the leaf stalk, enters the main stem. In a similar way the fungus may enter the stem through a fruit truss.

Control measures are therefore concerned with a careful regulation of the ventilation and circulation and humidity of the air and correct methods of defoliation and pruning.

When plants are infected as indicated by the diseased areas on the stem, they can only be saved by cutting out the brown portions of the stem and sterilising the wound with a strong solution of liver of sulphur or copper sulphate. In some cases it is sufficient to treat the outside of the lesion with a liver of sulphur solution so concentrated that it resembles a paste. The spores and parts of the fungus external to the plant may be destroyed by spraying or painting with a two per cent. solution of calcium bisulphite.

Mosaic Disease.

During the past ten years the attention of pathologists has been directed to a group of mysterious diseases known as mosaic diseases. This group has proved of considerable interest and is rapidly increasing in economic importance. The name "Mosaic disease" (Mosaikkrankheit) was first applied by Mayer in 1886 to a disease of the tobacco in which the leaves assumed a mottled distorted appearance. To-day the name is applied to a group of diseases the cause of which is unknown, possessing two very definite symptoms. The first is a mottling of the plant, in which light yellow patches alternate with those of a dark green colour or a distortion of the various parts producing blistered, irregular leaves and flowers. The second is the highly infectious character of the plant juices even after filtration through porous porcelain vessels.

The importance of the disease may be judged from the fact that practically one hundred different species of plants belonging to widely different genera have been reported as susceptible hosts. As these include many of the foodstuffs of the world, the economic importance of the disease cannot be over-estimated. While glasshouse growers are mainly interested in the fact that the tomato and cucumber crops are susceptible to this disease, it must not be forgotten that infection may be introduced from diseased plants of other species, and therefore a wide knowledge of the disease as a whole must be obtained if complete control is to be effected. During the past year, mosaic disease of the tomato and that of the cucumber have been studied.

Mosaic Disease of the Tomato.

The appearance of tomato plants infected with Mosaic disease varies considerably according as infection takes place in the early or late stages. Plants infected when quite young develop typical symptoms in all parts. They are generally stunted in growth and paler in colour than normal plants. Those infected later in life show typical symptoms only on those parts which develop after infection.

In respect of the foliage, five main types of symptoms exist and may be found singly on individual plants or together on the same plant. The first type consists of a simple mottling of the foliage without distortion of any kind. Pale green areas appear between the veins; in course of time, these turn yellow with an indistinct margin. The second type resembles the first somewhat but the spots produced appear very quickly, without gradual transition from pale green; they are distinct of outline and deep yellow in colour, like the variegation of *Aucuba Japonica*. It is probably similar to the *Aucuba-mosaic* of the potato described by Quanjer. The third type consists of a distorted leaf margin but without blistering or mottling. In the fourth type blisters are produced on the leaf surface and the leaf margin is more or less distorted. There is no mottling. The fifth type or tendril type is distinguished by a reduction of the lamina and the production of fern-like or tendril-like leaves. Mottling is absent. While a considerable amount of study is necessary before the facts are fully available, our researches have indicated that these symptoms are but manifestations of the same disease and that their appearance is governed by a number of factors, chief of which are the environmental conditions under which the host plant is grown and the degree of resistance exhibited by it. Thus most varieties of tomato plants inoculated in February and March develop distorted, blistered leaves without mottling; as the season advances these symptoms are gradually followed by mottling and distortion. Towards the end of the year the new leaves develop blisters and become distorted but mottling is rare. The type of symptom exhibited by the host may vary with the variety, even when the conditions are uniform. Thus mottling of the foliage in the case of *Manx Marvel* and *Invincible* occurs later in the year than it does in the case of other varieties, like *Kondine Red*, *Blaby* and *Comet*. The flowers of tomato plants suffering from Mosaic disease are frequently abnormal; cohesion and twisting of the various parts being fairly common. The anthers are sometimes quite small and sterile; many flowers droop from the pedicels at an early stage. Some workers claim that the fruits are frequently mottled but this symptom has not proved to be common in this country. The stems are often marked with streaks of a paler colour; occasionally small thin brown streaks are present.

The total effect on the plant of all these abnormalities is to reduce the weight and quality of fruit produced. Plants

physiologically weak are more severely attacked than the more robust, but in commercial nurseries the worst results are seen after the plants have been "stopped." This involves cutting away the growing point of the main stem just above the leaf situated above the fifth truss, in order to assist the fruit on the lower trusses to mature. Side shoots are then allowed to develop and produce what is known as the "tops." If an exceptionally heavy crop has been produced by the lower five trusses, the "top" may grow away weak and spindly; if infected with Mosaic disease at that stage, the effect is extremely bad. Mottling, distortion and desiccation of the leaves follows rapidly and the yield is negligible.

In the case of the tomato, a mottling or variegation of the leaves, which is apparently a form of malnutrition induced by unsuitable soil conditions, frequently occurs in some places. This, which is generally known as "Chlorosis" may be confused with true Mosaic if the basis of comparison is solely a macroscopic one. The two disorders differ materially in one respect, namely, the infectiousness of the plant juices.

Experimental Work.

1. The Infectious Nature of the Disease.

(a) Inoculation with raw unfiltered juice.

Twenty young tomato plants (Kondine Red) were inoculated as follows:—

Leaves showing mosaic symptoms were removed from an infected plant and crushed in a mortar. The juice was extracted under pressure, allowed to stand one hour to enable the coarse particles to settle and the supernatant liquid pipetted off. One leaf per plant was inoculated by placing six drops of the liquid (three on each side of the mid rib) and pricking through into the leaf tissues with a sterile needle.

After 14 days, mosaic symptoms appeared on all twenty plants, while control plants remained healthy during a period of 60 days, after which time they were removed. In order to prevent transmission of the disease by insects and the possible vitiation of results, these and all later experiments, unless stated otherwise, were conducted in chambers fumigated once a week, and in which no insects were observed.

(b) Filtration of the extracted juice.

Tomato plants eight weeks old, of the Kondine Red variety, were used in sets of twelve and inoculated as described in the previous experiment with infected juice filtered in various ways. The results are given on the next page.

Inoculation Material.	Date of Inoculation.	Appearance of first symptoms.	Number of plants out of 12 showing disease after 30 days.
Control.			
Unfiltered juice ...	Feb. 3rd, 1922	Feb. 18th, 1922	12
Juice filtered through Chamberland filter	Feb. 3rd, 1922	Feb. 19th, 1922	5
Juice filtered through Doulton filter ...	Feb. 3rd, 1922	Feb. 18th, 1922	4

These results indicate that the juice from a diseased plant retains its infectivity after filtration, but that passage through a porcelain filter reduces the amount of infection in the juice.

(c) The Inoculation of different varieties.

The following varieties of tomatoes in sets of ten plants were inoculated with infectious juice filtered through filter paper:—Ailsa Craig, Blaby, Blako, Buckley, Comet, Fillbasket, Ideal, Invincible, Kondine Red and Manx Marvel. Symptoms of the disease appeared on the 14th or 15th day, and of the varieties tested Fillbasket was the most susceptible.

Carrier plants.

Forty Ailsa Craig tomato plants and forty Kondine Red were inoculated with infected juice. After 32 days all the Kondine Red plants and 37 Ailsa Craig shewed disease symptoms. After 60 days three Ailsa Craig plants still shewed no outward signs of the disease. At this time the juice of each of these three plants was extracted and inoculated into ten healthy plants under controlled conditions. Thirteen days after, all the inoculated plants shewed symptoms of disease. This experiment was repeated on three occasions; the results obtained indicate that occasionally a tomato plant may be infected with Mosaic disease and yet shew no outward signs of being infected. In other words, "carrier" plants may exist.

2. Infection by Workers.

In order to test the truth of the supposition that the juice is carried from plant to plant by glasshouse workers the following experiments were undertaken:—

(a) Transmission of the disease by the hands.

The fingers of the investigator were thoroughly wetted with the juice from infected plants by crushing up a number of soft shoots and leaves. Healthy plants in batches of ten were then bruised in various ways by means of the infected fingers and the following results obtained.

Method of Inoculating healthy plants.	Number diseased out of 10 plants after 30 days.
Growing point nipped out	9
Stem crushed sufficiently to squeeze out a little juice ...	6
Side shoots removed	10
Young leaves rubbed and crushed between the fingers ...	9

The results indicate that the disease is transmitted readily by means of infected juice carried on the fingers.

(b) Disease transmission by the pruning knife.

In this experiment the stem of a diseased plant was cut by means of a sterilised knife so that some infected juice remained on the blade. Healthy plants were then trimmed with the infected knife, taking care to use the part of the blade previously contaminated. Ten healthy plants were treated in this way; after 30 days, seven of them were infected, first symptoms having appeared on the 14th to 16th day, after inoculation. It is thus apparent that the disease may be spread from plant to plant on the pruning knife.

3. Insects as Carriers of the Disease.

(a) Aphides.

A number of aphides reared from a single insect taken from a rose bush were fed on healthy tomato plants for 30 days. They were then transferred to plants suffering from Mosaic disease for a week, after which time they were placed on twelve healthy plants and finally removed after three days. Sixteen days after placing the aphides on the healthy plants, eleven of the latter developed disease symptoms.

(b) White Fly.

Two chambers containing diseased plants in pots on staging were used in this experiment. In each house six healthy plants were placed on the centre of the staging, surrounded by diseased plants. They were so arranged that the nearest diseased plant was two feet away. One chamber was infested with White Fly, while the other was kept free by fumigation with tetrachlorethane. In the first chamber all six healthy plants became infected with White Fly and shewed symptoms of mosaic disease in fifteen to seventeen days. In the second chamber the healthy plants remained so for the 60 days during which fumigation was maintained.

The results of these experiments indicate that the disease may be transmitted from plant to plant through the agency of such insects as the aphid and White Fly.

4. The effect of temperature upon the progress of the disease.

Observation made on plants inoculated under different temperature conditions have shewn that temperature has an important influence on the progress of the disease symptoms. In general the symptoms are most marked when the plant is growing most rapidly. Thus low temperatures, by retarding the rate of growth, prevent the development of characteristic symptoms, which are produced at temperatures suitable to rapid growth. In the early part of the year and at low temperatures there is a tendency to the blistering and distortion of the leaf without yellow mottling. At the higher midsummer temperatures mottling of the foliage is common.

5. The effect of manurial treatment upon the disease.

A very large number of pot experiments have been made in which inoculated plants were grown in various composts. The object of this was to determine the effect of different manurial treatments upon the progress of the disease, so that information might be available as to the best top dressing treatment for diseased plants. The results shew that with the exception of rather heavy feeding with a well balanced fertiliser, the treatments tested had no effect on the disease. This line of investigation is being continued.

6. Cross inoculations.

In attempting to control any disease it is always of assistance to know what other plants may harbour the disease organism, and act as infection centres. Cross inoculation experiments have been made between the tomato and other possible susceptible hosts. It has been shewn that Mosaic disease of the tomato may readily be transmitted to the petunia, tobacco, bittersweet, and black nightshade, and with difficulty to the potato. It is also possible to cross inoculate any of these from the other. Mosaic disease of the cucumber has not been transmitted experimentally to any of the above plants.

Mosaic Disease of the Cucumber.

Mosaic disease of the cucumber may readily be recognised. Two types have been observed in this country. One resembles the Aucuba type of the potato and tomato, being marked by localised yellow patches of distinct outline. Curling and distortion of the foliage is rare in this type, and apparently it does little damage to the plant.

The second type is characterised by mottling, wrinkling and blistering of the leaves and dwarfing of the plants. Infection takes place at an early stage and may lead to complete "blindness" of the growing point. As a general rule, only a small percentage of infected plants go "blind." The

majority continue to produce foliage bearing typical lesions, throughout the season. It has been observed that infected plants may produce normal foliage after a time but they cannot be said to have recovered, because their juices are still infectious. Infected plants continue to bear fruit during the season but the crop is considerably less than that from healthy plants. The flowers of diseased plants are smaller and paler in colour than normally. Mottling of the fruits may occur in advanced stages of the disease. As in the case of the tomato, the resistance of the host plant and its environmental conditions are of importance in determining the severity of the external symptoms. Thus the variety Butcher's Disease Resister grown in this country, on infection, shows only slight symptoms in comparison with other varieties commonly cultivated. The temperature of the soil and air are also important factors influencing the progress of the disease.

The Control of the Disease.

The elimination of centres of infection is an important control measure.

Neighbouring weeds as well as cultivated plants must be taken into consideration. Growers should make a careful examination of weeds and other plants growing in the immediate vicinity of the nurseries and any plants bearing symptoms suggestive of mosaic disease should be dug up and burned. No suspected plant should be given the benefit of the doubt. In relation to tomato mosaic it is now known that certain solanaceous weeds like the black nightshade, *Solanum nigrum*, and the bitter sweet, *Solanum dulcamara*, are susceptible hosts, and should be eliminated from the neighbourhood of tomato nurseries as they may act as centres for the spread of the disease. Similar dangers exist in the petunia and potato and manure containing potato tubers should not be used, as, if these contain the virus of mosaic disease, infection may spread from the infected shoots when these develop.

Alternative hosts for cucumber mosaic in this country have not been discovered and it is somewhat difficult to understand whence the infection comes, unless one accepts the statement which observation on commercial nurseries seems to confirm, that the disease is transmitted in the seed. There are no indications that tomato mosaic is carried in the same way.

In the case of sporadic infection of plants in a nursery in the early days of the season, care should be taken to remove immediately the affected plants before the disease can spread. In the case of mid season infection no useful purpose would

appear to be served by removing infected plants. The difficulty of effecting control by eliminating centres of infection, is owing to the fact that these are not always easy to identify when the symptoms are slight and in the case of "carrier" plants, shewing no outward signs of the disease, identification is impossible.

Careful attention should be paid to the transmission of the disease by workers and insects.

The complete elimination of insect carriers is almost impossible but much can be done by reducing the number to a minimum. The White Fly pest of tomato houses may be effectively controlled by hydrocyanic acid gas or tetrachlorethane, while aphides when present are easily controllable by many simple insecticidal fumigants on the market.

By careful education of the workers the rate of spread of the disease by this means can be reduced. They should be made to understand that merely crushing a diseased leaf and then bruising a healthy plant, thus conveying infected juices to it, is sufficient to transmit the disease. It is imperative in cultural operations that all diseased plants should be left until the healthy plants have been treated; in no case should a healthy plant be touched immediately after a diseased one. It is claimed that infection is spread by the clothes rubbing against a diseased plant and then a healthy one but this does not appear to have been confirmed experimentally. It has been shewn that infection by handling a diseased plant can be removed from the hands by washing with soap and water. Pruning knives which have been in contact with a diseased plant should be wiped on a rag moistened with some disinfectant such as lysol.

Report of the Entomologist.

The investigations concerning Animal Pests of Glasshouses have been confined mostly to a study of the control of Woodlice and Red Spider, but one or two other problems also required immediate attention. The work has been principally centred upon pests of the cucumber plant.

Woodlice (*Oniscoida*).

Woodlice are Crustacea (a class of animals comprising Shrimps, Crabs, etc.) which have become adapted to living on land and breathing air.

In the British Islands there are 30 or more different kinds of Woodlice, of which 11 have been found in cucumber and tomato houses in the Lea Valley; only five of them have appeared in any numbers, the others being casual intruders, entering the houses mainly in autumn, to shelter for the winter.

It is most noteworthy that only two kinds will breed to any extent in cucumber houses; both these seem unable to exist elsewhere, even in tomato houses, during any length of time.

Further, the most important of all economically, is a new species named, by the courtesy of Mr. H. G. Jackson, of the British Museum, after the author of this report, and described by him in the *Annals and Magazine of Natural History* (Series 9, Vol. XI., p. 224, February, 1923).

The following species must be regarded as pests:—

In Cucumber Houses.

<i>Armadillidium speyeri</i> , Jackson	...	...	In great numbers.
<i>Armadillidium pictum</i> , Br.	...	...	In smaller numbers.

In Tomato Houses.

<i>Porcellio laevis</i> , Lat.	...	...	In great numbers.
<i>Armadillidium vulgare</i> , Lat.	...	...	In great numbers.
<i>Haplophthalmus danicus</i> B. Lund.	...		often in great numbers.

General distinguishing characters of these Woodlice.

The three species of *Armadillidium* roll up into a ball when disturbed, and are thus distinguished from *Porcellio laevis*, which is unable to do so. All are of a slaty ground colour and, except for *Armadillidium pictum*, which is only $\frac{1}{5}$ th inch, attain a length of $\frac{1}{2}$ inch. In *Armadillidium speyeri*, which has a flattened body, the tail projects beyond the head when the animal is rolled up, and so a complete ball is not formed as in *Armadillidium vulgare*.

The latter is much rounder and more robust, and the flattened tail fits to the front line of the head, so that a complete sphere is formed when this woodlouse is rolled up.

Haplophthalmus danicus is a minute woodlouse, of a greyish white colour, unable to roll up into a ball, and attaining a size of only $\frac{1}{8}$ inch when full grown.

Habits of Cucumber-house Woodlice.

Armadillidium speyeri has been referred to as the most serious of Woodlouse pests in glasshouses. Possibly, the most damage is done by them in the early part of the year in the propagating houses. Curiously enough, they seem to confine themselves to gnawing the stems, and finally cropping off the cotyledons of tomato seedlings in the seedboxes, up to a week after germination; they leave cucumber seedlings of a similar age almost entirely alone. When tomato seedlings have reached a height of six inches they leave them alone, and do not touch the leaves or stem of this plant again, and we have no proof that they gnaw the roots of healthy tomato plants at any time. It is quite rare to find a cucumber seedling attacked by this woodlouse in a seedbox, but after potting,

when the third or fourth leaf is appearing, pear-shaped holes are eaten in the cotyledons, and both first and second leaves. Often the greater part of the leaf surface is entirely removed. Similar damage results still later to the older leaves of plants in the border, and here also the stems and roots are gnawed to a considerable extent.

The true food of this woodlouse, and probably of most others, consists of cellulose in a state of fermentation, so that an ideal means of sustenance is provided for them in the decaying straw of cucumber beds. That they can subsist on this alone is proved by the fact that a pair of these woodlice with their family have been kept in a thriving condition for over six months in a small glass dish into which nothing but a small amount of artificially fermented straw has been introduced from time to time. Although they feed chiefly at night, the woodlice are also active in the day time, provided that the temperature is above 60 deg. F. At a temperature below this they become less active but still continue to feed.

The males and females may be seen mating on the surface of the cucumber borders on bright May mornings. As in other woodlice, the female does not lay eggs but the young are hatched in a pouch on the underside of the thorax, from which they escape in June and early July. One female produces up to 50 young; there is but one mating and one generation in the year.

The young on hatching are minute white objects, which turn darker after a few days and attain almost the full colouring in a fortnight. They moult several times during the summer; there is a final moult for the year in October, when the young have attained a length of $1/5$ th inch. Thus the large forms which occur in the houses must be at least two years of age; this accounts for the vast numbers in nurseries where cucumbers are grown year after year. In the winter these woodlice congregate under clods of earth, in crevices, round pillars and under bricks, the two sexes being found in equal proportions. They very seldom burrow to a depth of more than four inches, even in loose ground; they are generally active during the winter months.

Armadillidium pictum is a small woodlouse with habits very similar to *A. speyeri*. Being found in smaller numbers, it is not so important economically. The young of the species appear to grow more slowly than that of *A. speyeri*; until the two were distinguished from each other, it was thought that the cucumber-house woodlice had two generations in the year: the very minute forms found in the soil at the end of the season in winter, however, all belong to the species *A. pictum*.

Invasion of Houses.

When the borders are taken out of cucumber houses, at the end of the season, woodlice are carried out in great numbers; if heaps of border soil are stacked near the houses the woodlice readily regain access to the houses out of which they were originally taken. Their habit of passing the winter in heaps of soil outside facilitates their introduction into the propagating house, in soil used for sowing seed and for potting. They may also be carried from house to house in pots and seedboxes.

Control Measures.

Hot Water Treatment.

Where apparatus is available for the distribution of water at a high temperature in glasshouses, the treatment is undoubtedly the most radical in the control of woodlice. To determine the effect of temperature on these woodlice, a thermostat was used in connection with a vessel containing soil into which they were introduced. With the water in the thermostat at 147 deg. F., the soil at an internal temperature of 146 deg. F., and with a surface temperature of 124 deg. F., all woodlice introduced on the soil surface were killed in 30 seconds.

With the thermostat temperature at 140 deg. F., the soil internally at 136 deg. F., and the soil surface at 108 deg. F., woodlice similarly introduced were killed within two minutes. Woodlice dipped for $\frac{1}{2}$ second in water at 149 deg. F., died within a few minutes after the immersion. These experiments show that the *Armadillidium* is easily killed by water at comparatively low temperatures, and also why the hot-water treatment is so effective.

Winter Treatment:

It was considered that the method in use for cleansing houses with Cresylic acid and soft soap emulsion in 1921 was inadequate for killing woodlice and the following method was devised and is recommended:—First clear out the borders, for it is not possible to reach the woodlice with the spray recommended when they are buried in the loose soil. When doing so, do not stack the manure and soil near the houses, but cart away and spread them on land at some distance. If this precaution is not taken, the woodlice will get back into the houses. Flood the soil surface with water, after breaking up clods of earth under which the woodlice can find protection: this will drive them to the surface and many will ascend the walls. Immediately after floodling, spray the whole of the soil surface, the walls up to the gutter and especially crevices, pillars and cement, with the following emulsion:—

Potash Soft Soap (household)	...	...	8 lbs.
Cresylic Acid (pale straw 97-99%)	...	...	1 gallon
Pure Naphthalene	...	...	$\frac{1}{2}$ lb.

These are heated together in a bucket till the soap is all melted and the naphthalene completely dissolved. The undiluted emulsion will keep indefinitely. For spraying use 2 pints to every 12 gallons water. Do not let the dilute mixture stand any length of time, otherwise the naphthalene will fall to the bottom of the sprayer as a precipitate.

When possible, spray the mixture round the base of the walls outside the houses, after removing all unnecessary bricks or woodwork which may afford the woodlice protection. If apparatus is available the use of boiling water applied after the borders have been removed may be substituted for this treatment.

Result this of Treatment.

A cucumber house of 15ft. $\times$ 12 $\frac{1}{2}$ ft. (1,000 cubic feet space) was treated exactly as described above in November, 1922. Before the soil was cleared out, however, as many woodlice as possible were collected from the borders: we give the figures as they show roughly the proportions of the different kinds of woodlice living in the borders.

<i>Armadillidium speyeri</i>	...	...	...	...	292
<i>Armadillidium pictum</i>	...	...	...	...	29
<i>Armadillidium vulgare</i>	...	...	...	...	31
<i>Philoscia muscorum</i>	...	...	...	...	1
<i>Metapornothus pruinosus</i>	...	...	...	...	1
Total	...	...	...	...	354

These would mostly have been removed with the border soil. Two days after spraying with the emulsion recommended another collection was made from one side of the house only.

				Dead	Living
<i>Armadillidium speyeri</i> and <i>A. pictum</i>	...	...	...	481	5
<i>Armadillidium vulgare</i>	...	...	...	98	1
<i>Metapornothus pruinosus</i>	...	...	...	1	0
Total	...	...	...	580	6

This represents a mortality of just under 99%; the efficiency of the mixture is due in part to the cresylic acid and in part to the naphthalene. Cresylic acid acts in two ways upon woodlice chiefly as a contact poison and to a slighter degree as a fumigant. When used in a rough mixture with water,

when an even distribution cannot be obtained, the animals receive minute particles of pure cresylic acid upon them which kills them very quickly. When mixed with soft soap, however, this contact effect is lost and the fumes, which are fatal to Red Spider and certain soil organisms, are insufficient to produce a high mortality amongst woodlice which can gain a certain amount of protection in the soil.

Naphthalene itself has a contact as well as a fumigant action on woodlice. The fact that it is evenly distributed through the mixture recommended makes up very largely for the loss in contact efficiency occasioned by the mixing of soft soap with the cresylic acid, a necessary measure for the even distribution of the latter.

Experiments in Control.

Poison Baits.

It has been remarked that these woodlice feed for the most part upon decaying cellulose, and that they obtain an ideal supply of food in the cucumber borders. This makes it a matter of great difficulty to attract them with any substance used commonly in baits. As an attracting basis coarsely ground *oatmeal* has been found more useful than bran, flour or starch; it becomes specially attractive to the woodlice when mixed with glucose or treacle. Lævulose, saccharose, mannite and glucose were tested; the last appeared to be most attractive. As to poisons, arsenical compounds are usually recommended, and are contained in several proprietary baits. In our experiments, which were carried out with various arsenical compounds, we have stained the poisoned oatmeal with cochineal, and after several days have dissected the woodlice to make sure that they have eaten the bait, the red cochineal being readily detected in the stomach of the woodlouse. In not a single case has a woodlouse died from eating these poisons, although in all cases, the bait has been found in the intestines of the animal when dissected.

After a number of unsuccessful trials with compounds containing copper, it was found that substances containing chromium had the desired effect, the soluble bichromates being the most satisfactory: of the latter, potassium bichromate when used in a solution above $2\frac{1}{2}\%$ strength caused death in every case. Solutions containing but a trace of potassium bichromate when injected into the bodies of woodlice have produced almost instant death.

A bait consisting of	Oatmeal	...	...	...	10 parts
	Glucose	...	...	...	2 parts
	Potassium bichromate	.			1 part
	Water	...	...	...	10 parts

costing about 3d. per lb., which acted consistently on woodlice kept in jars and dishes, was only successful to a slight degree when used on cucumber borders, owing to the difficulty of attracting the animals from their natural food. It still remains, however, to give this bait a trial in the propagating house, where it will be more useful, being distributed at times when the woodlice are short of food.

Pot-trapping.

The use of inverted flower-pots filled with straw has long been in vogue for catching woodlice.

The following tables show the numbers caught with various materials in the pots.

November, 1921.—Average number caught in one pot per night on cucumber house subsoil.

Substance.

Average number caught in one pot over four days.

Common straw treated with boiling water	43
Border straw + dung untreated	74
Ditto, treated with boiling water	104
Fermented straw	154
Common straw treated with boiling water + molasses	272

August, 1922.—Actual numbers caught in 1 pot per night on cucumber border with growing plants.

Substance.

	Numbers caught in one pot.				Total
	1st day	2nd day	3rd day	7th day	
Common straw, untreated ...	2	2	0	3	7
Common straw, untreated + 5% glucose	5	7	2	8	22
Fermented straw	3	15	30	43	91
Fermented straw + boiling water	0	4	0	0	4

On another border—

	1st day	2nd day	3rd day	7th day	Total
Fermented straw	200	170	125	50	545
Fermented straw + 5% Pot. Bichromate ...	38	100	14	8	160
Fermented straw + 10% Pot. Bichromate ...	0	2	0	0	2
Fermented straw + 10% Calcium Bichromate ...	2	0	0	5	7
Common straw, untreated	530	32	0	14	576
Common straw + 10% glucose	2,500	200	12	0	2,712

These figures show that fermented straw is more attractive than unfermented, and that the addition of glucose to common straw increases its attractive qualities; that addition of potassium or calcium bichromate makes the straw distasteful; and that the attractive ingredients in fermented straw are soluble in water and can be extracted.

Further, that in a given area, the number of woodlice decreases with consistent pot-trapping. Any method of this kind is laborious on a large scale, and is only successful over limited areas.

Tomato-house Woodlice:

Armadillidium vulgare is often present in very large numbers in the soil of tomato houses. In the winter, these woodlice (the two sexes in approximately equal numbers) collect round the walls of the houses, and when the temperature falls, bury themselves to a great depth in the ground. They have been dug up 18 inches below the subsoil surface. They seldom destroy tomato plants in the seed box, and only occasionally gnaw the stem of a cucumber seedling, so that the part which they play in the houses is not very clear.

In the spring they may be caught in great numbers by placing mangolds cut in half at intervals on the ground, with the cut surface downwards. At the Experimental Station they seemed to disappear in June, and it is thought that they may leave the houses to breed and only return for the winter. At any rate, they were found in great numbers under boxes, pots and especially in ants' nests outside the houses during the summer. Their numbers in cucumber houses is often great in winter, but hardly one has been found between May and September. They were poisoned by an oatmeal bait containing potassium bichromate, just as *A. speyeri* were in experiments already alluded to. When buried deep in the subsoil it would be difficult, however, to reach them either with hot water or any contact poison, but from all observations, it seems that they are not very harmful to the grower.

Porcellio laevis is a surface woodlouse, much more readily killed by cresylic acid soft soap emulsion than the *Armadillidium* species. It is thought that *Porcellio*, which is a very common woodlouse outside, simply enters houses for the winter, and has not yet been observed to do any damage in the propagating houses.

Haplophthalmus danicus, possibly a root feeder with very obscure habits, is found at the end of the season on the surface of the soil in large numbers, when it is killed at once by treatment with cresylic acid emulsion.

Red Spider (*Tetranychus telarius*).

Winter Habits.

There has been some doubt as to whether the "red" hibernating stage was the only one in which Red Spider was able to pass the winter.

Our observations, both inside and outside glasshouses, now lead to the conclusion that this is so, and that neither the eggs nor any immature stage can survive the winter months, even if food plants are constantly at hand. In the early year, it has been found that, with the heating of the houses, some adults may come out of hibernation and lay eggs on young cucumber plants, but in no case have the larvæ hatching from eggs of the second generation reached maturity, and they usually die before the first moult. The comparatively large area of leaf which is visibly affected by only a few individual spiders is liable to give the impression of a severe attack, especially on young plants in the spring. Several such attacks were examined this year; in all cases, the damage was due to less than ten individuals on a leaf.

We have reason to believe, though it is not yet proved, that the adults which lay their eggs early in the year are unable to do so later. In this event, any drastic control of spider on young pot-plants is to be deprecated.

The young spiders attack the first leaf of pot-plants and have rarely been observed at all on cotyledons and the second leaf. Later, the second, third and fourth leaves may become infected, but the principal damage is still confined to the first leaf in the case of well-grown plants.

Fumigation.

A large number of experiments have been carried out with gases and vapours upon Red Spider in various stages of development. Negative results were obtained with the following:—Chlorine, Nitrogen tetroxide, Carbonyl sulphide, Hydrogen disulphide, Selenuretted hydrogen and Carbon bisulphide.

Hydrogen cyanide and Cyanogen iodide anaesthetised the spider. Sulphuretted hydrogen was the only gas tested which had an appreciable effect in killing spider when concentrations varying between 1 volume of gas in 1,500 of air and 1 volume of gas in 200 volumes of air were used.

The lower concentrations, when applied over a period of 16 hours, and the higher over a period of one hour, killed in most cases a very large percentage of spider in all stages except the egg, but we do not feel justified in giving actual figures until a large series of experiments has been completed.

Having seen the effects of the gas on spider and on plants in the laboratory, increasing quantities of the gas were generated from iron sulphide and dilute hydrochloric acid in a house of 1,000 cubic feet space; we can only say that the gas, under these conditions, failed to produce the expected action on spider and was entirely innocuous to the cucumber plants. It seems reasonable to suppose that, in some way or other, sulphuretted hydrogen disappears from the atmosphere too rapidly to allow of sufficient concentration being obtained in so large an air space.

Of the organic gases and vapours tested, Formic Acid and Ethyl mercaptan had no effect on spider, while Amyl nitrate and Tetrachlorethane acted only temporarily. Methyl nitrite and Chlorpicrin had a more permanent effect on spider but it was necessary to use concentrations which caused considerable damage to the plants. It was noticeable that, with the exception of Formic Acid and Ethyl mercaptan, the adults of White Fly were killed by all the gases and vapours used.

Cucumber Root-Flies (*Sciariidæ*).

A remarkable amount of damage has been sustained by cucumber growers this year through the attacks of certain Mycetophilid flies, commonly known as "Fungus gnats," belonging to the family *Sciariadæ*.

Outbreaks occurred as follows:—

In January, at Enfield Wash: severe damage to pot-plants by the grubs of *Pnyxia scabiei* Hopk.

In May, in the Worthing and Dartford districts: very severe damage to plants in the borders by the grubs of *Plastosciara perniciosus* Edwards, and *Pnyxia scabiei* Hopk.

In September, at Hoddesdon: damage to plants in the border by the grubs of *Plastosciara perniciosus* Edwards.

Life History of these Flies.

Pnyxia scabiei.—The female fly is wingless: the males are of two kinds, one with long, the other with short wings. They run quickly on the surface of the soil, in which they readily hide, and are only about one-sixteenth of an inch in length. After mating, the female fly lays 20 to 30 white eggs just below the surface of the soil, and not on the stem of the plant. The eggs hatch in 5 to 6 days to white grubs with black heads. The grubs attain a length of over one-eighth of an inch, and if the moisture in the soil becomes deficient, burrow into stems and tap-root of the cucumber plant below and sometimes even for a short distance above the ground surface. Here they feed upon the plant tissues for a week, when they leave the hollowed stem and turn to the pupal stage in the soil, surrounding themselves with a dark silky

cocoon, which is difficult to find. The adult flies emerge three days later and lay eggs less than a week afterwards. The broods of flies appear every three weeks. From the root-stem of a single young pot-plant, as many as sixty grubs have been extracted, and their feeding causes the leaves to droop through a total destruction of the tap-root.

*Plastosciara pernicios*a Edwards has habits similar to *Pnyxia scabiei*, but the female has wings and much resembles the male in appearance, both being darker in colour than the latter fly. The flies swarm on bright mornings, and may be seen in thousands where a severe attack occurs.

Control Measures.

The grubs and flies are brought into the house with manure and in potting soil. They have been observed in tomato seed-boxes, and in cucumber and tomato houses where no damage has been recorded. Throughout the season, *Pnyxia scabei* was present in considerable numbers in the houses at the Experimental Station, where, however, the grubs never appeared to attack the plants.

In every case where there has been damage, it was found that the plants, whether in pots or in the border, had been watered insufficiently, thus diverting the grubs from the organic matter in the soil, upon which they normally feed, to the succulent roots of the plants. After unsuccessful trials with many chemicals, it was established that an excess of water in the soil killed the grubs in a comparatively short time: accordingly, pot-plants were left standing in water for twelve hours, with the results that all the grubs in the soil and plant root were killed outright and many adult flies were drowned. Later, a good flooding of the cucumber borders gave the desired result and most severe attacks were placed under control in the course of a few days.

Note.

*Plastosciara pernicios*a is a fly new to science, and has been described by Mr. F. W. Edwards, of the British Museum, in the "Entomologist's Monthly Magazine" for July, 1922, from specimens sent from this Experimental Station.

Pnyxia scabei is described in detail by Dr. A. D. Hopkins in the Proceedings of the Entomological Society of Washington, D.C., Vol. III., 1895, and was one of the causes of potato scab in the United States. An account of the life-history, habits, and control of these two flies, with illustrations, has appeared in the Bulletin of Entomological Research (Vol. XIII., pt. 3, January, 1923).

Notes on Fumigation.

(a) Tetrachlorethane.

Severe damage to a white variety of Pelargonium, through fumigating for White-Fly with a proprietary fumigant containing Tetrachlorethane, having been reported by the West Kent Growers' Association, and similar circumstances having previously arisen in the case of certain varieties of Chrysanthemum at the Experimental Station, a number of different plants were placed in a house of 1,000 cubic feet space, and fumigated with 10 ounces of Tetrachlorethane on the night of May 11th.

The following pot-plants were used in the experiment:—

Fuchsias.

Geraniums.

Pelargonium, Var. Chlorinda, Var. Don Juan.

Tomatoes.

Chrysanthemum, var. Ethel Harvey.

„ Improved Massie.

„ Pink Pearl.

„ Betty Spark.

„ Elsenham White.

„ J. Bannister.

At 6 a.m. on May 12th, and afterwards, the Fuchsias, Geraniums, Tomatoes and Pelargoniums were unaffected by the fumigation. Of the Chrysanthemums, however, Elsenham White alone remained unharmed. The other varieties were damaged in the following manner:—

Ethel Harvey—All the leaves severely scorched.

Improved Massie—Lower leaves brown; upper leaves drooping and with veins brown.

J. Bannister—Lower leaves considerably scorched; upper leaves drooping and discoloured in patches.

Pink Pearl—Lower leaves discoloured; upper leaves unaffected.

Betty Spark—Lower leaves discoloured; upper leaves unaffected.

By May 15th, Ethel Harvey and Improved Massie were entirely dead. The upper leaves of Pink Pearl and J. Bannister had recovered, while those of Betty Spark were curled, but not dead. The last three varieties finally recovered.

The experiment illustrates a remarkable case of varietal susceptibility to the vapours of Tetrachlorethane shown by certain plants. It must be noted that the varieties of Pelargonium used in the experiment were different from those reported as damaged by the White-fly fumigant.

(b) Amyl Compounds.

During experiments in fumigating Red Spider, it was noted that the grubs of a Chironomid fly, *Orthocladius*, came to the surface of the soil of Cucumber pot-plants, and were killed in a short time when Amyl nitrite and Amyl nitrate were used. It is probable that Fusel Oil, which contains a great quantity of Amyl alcohol, and which is soluble in water, exercises a similar influence on these grubs. The latter is less injurious to plants than the two compounds previously named.

Another case of the same kind was experienced with Tomato seedlings, in the stems of which *Camptocladius* grubs were living.

Investigations upon the fertilising effects of carbon dioxide.

L. B. TIMMIS.

The investigations were planned in two sections. The first attempted to determine the carbon dioxide content of the atmosphere in cucumber houses under normal treatment, special attention being directed to the variation of the concentration in different parts of the house at different times of the day.

The second was concerned with an attempt to maintain a constant concentration of carbon dioxide (ten times normal) in a small glasshouse.

PART I.

The Carbon dioxide content of the atmosphere in cucumber houses under normal working conditions.

The recent experiments of other investigators have drawn attention to the possible increase in crop yield which may be produced by increasing the concentration of carbon dioxide in the atmosphere. So much so that experiments along these lines have been undertaken in this country in relation to glass-house cultivation.

The logical beginning of such investigations must necessarily be the determination of the normal concentration of carbon dioxide in glasshouse atmospheres and the study of any variations which may occur.

In the present paper the result of preliminary investigations are set out,

A note on this subject was published in the Second Annual Report of this Station (1916). It is there stated that in cucumber houses, (1) the atmospheric carbon dioxide is stratified, being most concentrated at the soil surface (9 to 14 parts per 10,000) and most dilute at the top of the house (4 to 5 parts per 10,000); and (2) at any given level the concentration of carbon dioxide is greater at night than during the day.

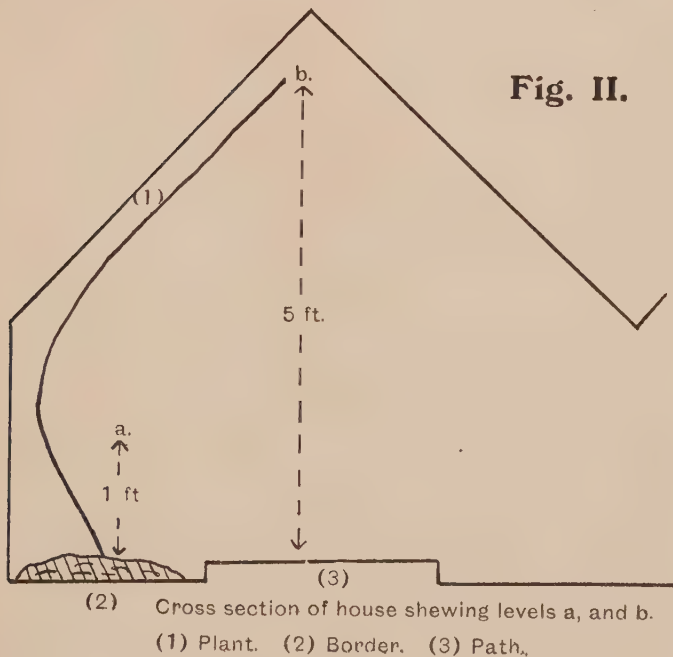
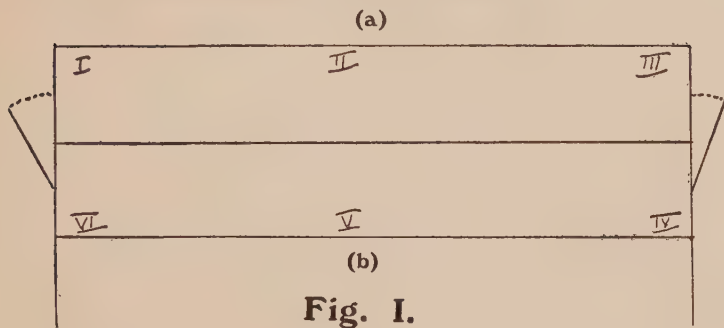
The present investigation, so far as it has proceeded, confirms and amplifies the second conclusion but indicates that the first may not be generally true in the Station experimental houses. The work is still in progress but the following general results may be stated provisionally, concentrations of carbon dioxide being expressed throughout as parts per 10,000 by volume.

During the day, when ventilation is induced, the concentration varies irregularly at different levels and in different parts of the house. Sometimes (see Series I.) very little variation is found from the normal 3. Again, the concentration may be 6 at certain points, the average value at that time being lower. Readings below 2.4 are very rare under any conditions. A very regular change has always been observed during the period when the house has been closed down at night, that is, between about 8 p.m. and 6 a.m. Readings taken at 8 p.m., 12 midnight, 1.30 a.m., 3.30 a.m., and 6 a.m. show that the amount of carbon dioxide increases gradually, reaching a maximum between 3.30 a.m. and 5.30 a.m. During this process there is at no time a very marked graduation of concentrations from the soil to the top of the house, and the 5 or 6 a.m. observation (Series II. and III.) shows an even distribution at a concentration of 10 to 13 parts. On opening the houses for work in the morning this falls very quickly to the values already mentioned. Two experiments in which the house remained closed until 11 a.m. (Series IV.) were undertaken and a rapid decrease in the concentration of carbon dioxide which may be attributed to its assimilation by the plants, was observed. This is to be further investigated.

Experimental Details.

The analyses were performed by means of a portable Haldane apparatus; the samples being collected in 2 oz. glass bottles and transferred to the apparatus with a mercury trough, according to Haldane's method. All the results are expressed as parts per 10,000 by volume.

Plan of House showing positions I. to VI.

**Series I. and II.**

SERIES I.—Samples were taken from three places on each side of the house at the same levels (Fig. I, a and b).

July 10th.	I.	II.	III.	IV.	V.	VI.
7.30 p.m. (a)	3.0	3.0	3.2	3.7	2.4	2.6
9.0 p.m. (b)	3.5	3.4	4.5	4.0	4.2	3.5

These observations showed that at each of the two given levels the concentration of carbon dioxide varied very little from the normal for different parts of the house.

SERIES II.—As it was desirable to make observations along the two levels simultaneously, samples were taken as in Series I. but at one side of the house only and at the two levels (a) and (b) (Fig. II.).

			I.		II.		III.	
July 11th.	10.30 a.m. (a)	...	3.0	...	2.7	...	2.7	
	(b)	...	3.0	...	—	...	4.0	
July 12th.	7.30 a.m. (a)	...	6.7	...	4.0	...	5.5	Top dressing previous afternoon.
	(b)	...	3.0	...	4.2	...	3.0	
July 13th.	5.45 a.m. (a)	...	10.2	...	12.5	...	11.2	
	(b)	...	10.2	...	12.5	...	11.5	
	7 p.m. (a)	...	4.0	...	3.0	...	5.4	
	(b)	...	—	...	4.5	...	2.5	
July 14th.	5.45 a.m. (a)	...	12.5	...	9.4	...	9.2	
	(b)	...	5.5	...	12.6	...	7.0	
	8.0 p.m. (a)	...	3.5	...	3.1	...	6.2	
	(b)	...	5.0	...	4.7	...	5.2	

The two sets of readings at 5.45 a.m. clearly indicate an increased concentration ; in the first case (July 13th) there is an even vertical distribution at each of the three positions and little difference between them; in the second (July 14th) there is more irregularity. The rest of the readings show minor variations from which no certain deductions can be made.

Series III. and IV.

The analyses in this series were taken at the centre of the house (portion II., Series I. and II., at six different levels).

These levels shown in Fig. III. were marked out in the house by means of stakes of different heights. For I., the sample bottle was laid on the soil; II., III. and IV. being among the foliage and V. at the top of the plants.

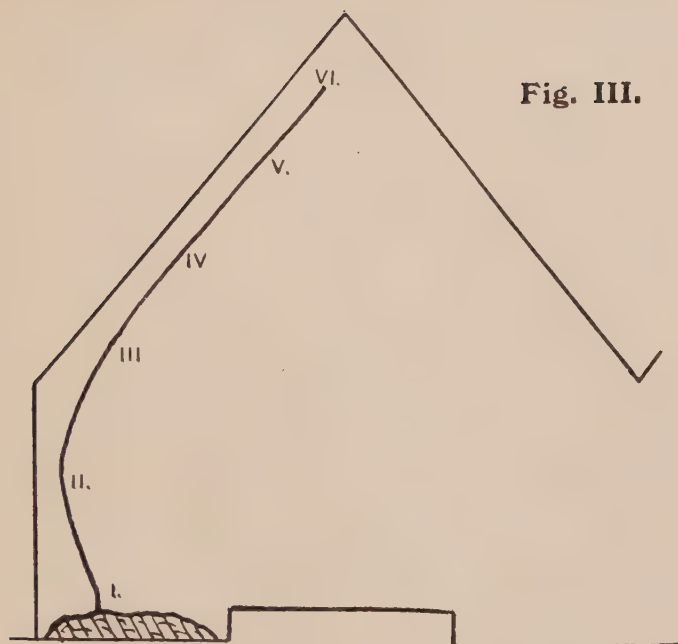


Fig. III.

SERIES III.—The concentration of carbon dioxide at six levels at different times of the day are tabulated below.

Date	Time	Levels.					
		I.	II.	III.	IV.	V.	VI.
July 18th	11.0 a.m.	2.5	3.5	7.0	3.0	8.5	3.2
	7.30 p.m.	4.3	5.0	12.0	7.8	—	5.4
	12 midnight	7.5	6.4	6.7	6.0	5.0	5.5
July 19th	3.30 a.m.	9.0	6.2	—	8.7	7.5	7.7
	*6.0 a.m.	6.5	7.0	7.7	7.0	4.7	5.2
July 20th	5.30 a.m.	9.4	9.4	10.9	10.6	10.5	9.2
	4.0 p.m.	3.0	3.0	1.0	3.0	2.1	2.5
July 21st	*6.10 a.m.	7.2	3.6	5.7	7.0	8.3	8.2
	12.30 p.m.	3.0	4.4	3.0	4.0	3.2	3.0
July 25th	3.30 p.m.	3.3	3.5	2.3	1.5	3.0	4.3
July 26th	6.30 a.m.	10.7	9.4	—	10.0	10.0	11.5
Aug. 3rd	6.30 a.m.	13.0	13.8	12.6	13.5	—	12.4
Aug. 5th	6.30 a.m.	12.7	11.5	17.4	9.0	12.2	13.0

* Picking in progress.

This series leads to the conclusions already set out in page 58.

SERIES IV.—Two experiments were carried out keeping the houses closed down and taking readings as in Series III. at early morning and about noon.

August 2nd			6.30 a.m.	11.20 a.m.	
I.	...	...	13.0	...	5.2
II.	...	...	12.3	...	4.0
III.	...	...	11.1	...	3.7 (3 hours
IV.	...	...	10.2	...	4.0 bright sun)
V.	...	...	10.5	...	5.0
VI.	...	...	11.6	...	5.4

The above experiment indicates that a marked reduction of the concentration of carbon dioxide takes place in the atmosphere of a cucumber house exposed to bright sunlight for three hours when the house remains closed; this is what would be expected from the assimilative activities of the crop.

PART II.

Experiments in supplying carbon dioxide to a glasshouse of 1,000 cu. ft. capacity.

An end chamber of 1,000 cu. ft. capacity, of an experimental glasshouse, was adapted for these experiments by fitting felt packing round the vents and the door and filling in the glass overlaps with putty. A supply of carbon dioxide was provided from a cylinder in the corridor of the house, the gas being passed through a large washbottle containing sodium bicarbonate solution, to remove any acidic impurities. From this it was led through an ordinary gas meter into the chamber by lead piping terminating in a horizontal pipe half-way up the roof and extending three-quarters of the length of the chamber. The gas was emitted from a number of perforations, about six inches apart in the under-side of this pipe. Similar sections of the house, respectively adjacent and opposite to this chamber, were selected as controls.

It was desired to maintain the proportion of carbon dioxide in the atmosphere of this chamber as nearly as possible at 30 parts per 10,000, i.e., 10 times the normal. Theoretically this required an addition of about 3 cu. ft. of gas.

The carbon dioxide was at first added at the rate of about 1 cu. ft. per hour; a more rapid rate tending to choke the connections by freezing.

Using this method, a sample taken at a place 3 ft. from the ground during the passage of the gas would give readings from 12 to 15 parts of carbon dioxide per 10,000; but half-an-hour after the gas was turned off analyses at various levels gave

values which in no case exceeded 9 parts; and in the course of a further two hours the values fell almost to normal.

The following experiment indicated the manner in which the gas was lost by absorption into the soil :—

10 cu. ft. carbon dioxide were added.

One hour after addition 1 ft. above ground. 10 parts carbon dioxide.

4	"	"	11	"	"
8	"	"	7	"	"

A sample drawn from a hole dug about 2 inches down in the floor of the house gave 64 parts of carbon dioxide. It may be assumed that the air in the soil was actually much richer in carbon dioxide than this and that some of the upper air was included in the sample.

It now became necessary to devise a means of mixing the carbon dioxide with the atmosphere of the house. The obvious method of doing this was to use a fan, but as the power to work it is not at present available other means were tried. These having been unsuccessful, it appears that a fan will eventually be necessary. It may be noted that in the Riedel plant for glasshouses, the carbon dioxide is added to 9 times its volume of air and the mixture passed into the house by a fan.

The device shown in the accompanying diagram (Fig. IV.) was tried, but only slightly improved mixing of the carbon dioxide was obtained with it; its use has been discontinued.

It consists of a bent stove pipe, 5 inches in diameter, of the shape shown, suspended above a "Primus" stove which was kept alight while the carbon dioxide was supplied, in the first experiments, to a perforated pipe above it; and later through a $\frac{1}{4}$ inch pipe passing half-way up the vertical limb of the stove pipe.

The following is a typical analysis of the air after applying carbon dioxide by this method :—

Added 3 cu. ft. of gas.

Analyses 2 ft. above the border, 8 hours after adding gas :—

6.7 parts per 10,000 of air.

Even if the distribution of the gas had been satisfactory the extra heat would have rendered comparative experiments with a control chamber unreliable; and products of combustion, other than carbon dioxide and water might introduce an unknown factor.

A modification of the first experiment was next attempted, the carbon dioxide and two control chambers having been replanted.

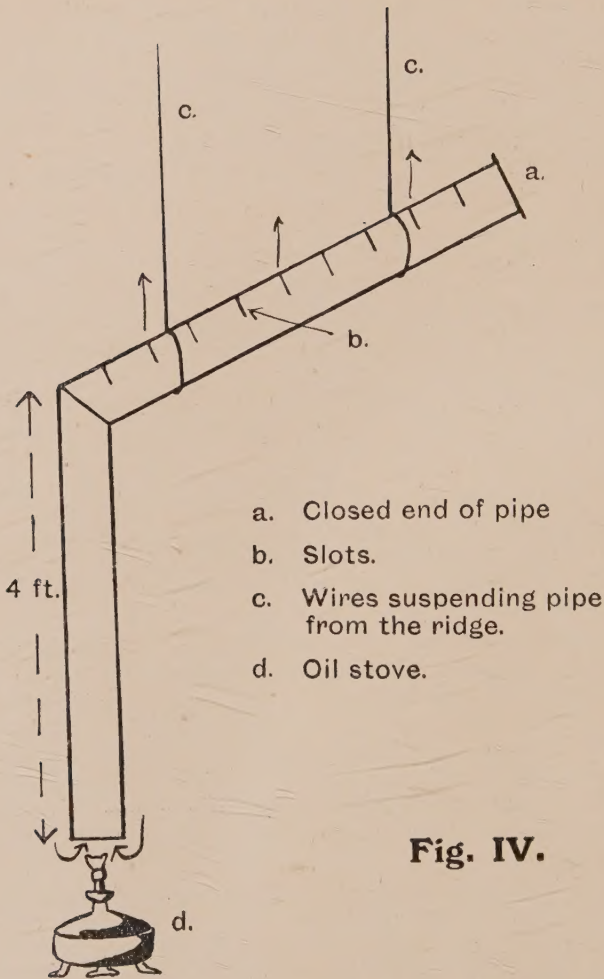


Fig. IV.

The gas is being supplied through an automatic pressure regulator at a very slow rate, continuously day and night, using the original perforated pipe at the top of the house.

The work already described and carried out by Mr. Timmis was repeated with slight modifications in a second cucumber house during the first half of October by Mr. Owen. Generally speaking, the results confirm the conclusions set out in his report. From other experiments it seems fairly clear that, if stratification does exist, it is of such an order that the Haldane method of analysis will not detect it.

With regard to the mixing of extra carbon dioxide with the air, experiments are now being made with a fan, and if these are successful, attempts will be made to determine, approximately, at all events, the effects of the various factors which may influence the carbon dioxide concentration.

During the coming season it is hoped to carry out work on the following lines:—

- (1) Examination of the glasshouse atmosphere for stratification by both the Haldane and Pettenkofer methods of analysis.
- (2) Examination of the effect of varying concentrations of carbon dioxide on plant growth and on crop yield.

Meteorological Records, 1922.

Month.	Rain.		Average outside Temperatures.		Bright Sunshine.
	Total fall. 5 inch Funnel Gauge.	No. of Rainy Days.	Day Maxm. °F.	Night Minm. °F.	Daily average in hours.
	Inches.				
January	3.13	21	44.0	33.7	1.30
February	2.16	16	46.3	34.7	3.26
March	1.76	15	46.6	35.7	3.55
April	2.85	17	50.7	35.6	5.20
May	1.20	7	67.2	46.4	8.98
June	1.33	10	67.9	49.4	7.73
July	3.75	20	65.5	50.9	4.95
August	2.42	15	65.1	50.5	4.43
September	2.45	14	61.8	47.0	3.73
October... ..	0.82	12	54.1	40.4	4.28
November	1.26	9	47.7	35.5	1.52
December	2.98	17	46.2	37.3	1.36
Total or Mean...	26.11	173	55.3	41.4	4.19

Dates of Cultural Operations during 1921—1922.

Crop.	Sown.	Potted into 60's.	Potted into 32's.	Planted out in borders.	First Mulching.	First Top Dressing.	First Fruit Picking.	Last Fruit Picking.
Tomatoes ...	Dec. 19, 1921.	Jan. 23, 1922.	—	Mar. 1	May 5	May 13	May 22	Oct. 27
Cucumbers ...	Dec. 19, 1921.	Dec. 28, 1921.	Jan. 16, 1922.	Feb. 15	—	Mar. 2	Mar. 20	Oct. 20